JOURNAL
OF
ECONOMIC ENTOMOLOGY
OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
VOL. 6 DECEMBER, 1913 No. 6

THE RHINOCEROS BEETLE (ORYCTES RHINOCEROS L.) IN SAMOA

By R. W. DOANE, *Stanford University, California*

The following notes are based on studies made by the author in Samoa during May, June and July, 1913.

The rhinoceros beetle, *Oryctes rhinoceros* L., has long been known as a more or less serious pest of coconut trees in many tropical countries. It is gradually extending its range and wherever it gains a foothold in a new country its ravages cause much worry and usually great financial loss.

The island of Upolu, German Samoa, is one of the recent places to suffer from the introduction of this pest. Its presence there was first noticed in the fall of 1910 when the ragged condition of some of the trees near the customs house in Apia caused an investigation to be made. As soon as their characteristic work was recognized there was evidence on every hand to show that the beetles were already well established there. Within a restricted area many of the coconut trees were badly injured and the larvæ were found abundantly in decaying wood, manure and other refuse. Just how the beetle was introduced into Samoa will probably never be known, but it is quite likely that young larvæ were brought in with soil and vegetable refuse packed around the stumps of rubber trees imported from Ceylon.

Unfortunately systematic attempts were not made to exterminate the pest when first discovered. Certain control measures were adopted but the fight was not carried on vigorously enough to keep the beetle from gradually spreading to all the districts near Apia and later to more distant parts of the island.

The prevailing northeast trade-wind has been a determining factor in the direction of the spread of the insect, the districts to the windward of Apia showing comparatively little damage. In the other direction practically all of the plantations are more or less affected, the infestation having passed around the end of the island and for

some distance up the other side. The beetle has also very recently appeared in limited numbers in the island of Savaii where it has probably been carried by the natives who are constantly passing back and forth, carrying quantities of mats, food and many other articles in which the beetles and larvæ or eggs might easily be transported.

In districts where infestation is the worst, hundreds of trees are being killed on many of the plantations and others are being so badly injured that, even should they recover, it will be some years before they will have a good crop of nuts.

As the beetles attack the most vital part of the tree, the succulent crown, one or two will quickly kill a young tree. Older trees are able to sustain greater loss but even a few beetles in them will soon make them unproductive, and, as the trees are sometimes attacked by as many as ten or fifteen beetles at once, even the sturdiest trees may succumb. The beetles usually attack the tree close to the base of some of the leaves, between the base of a leaf and the tree, or between the bases of two leaves. They are thus enabled to use their legs to brace themselves firmly while beginning their burrow. The strong curved horn on the head is also called into use as the beetles gnaw their way through the tough fiber. The head is lowered and the horn thrust into the fiber, then as the head is raised the body is drawn forward. As the beetles are usually an inch and a half long and about an inch in diameter the holes that they make in the base of the larger leaves are very conspicuous, particularly as the older leaves die and hang down. On their way toward the center of the plant the beetles usually cut through some of the young leaves, the pinnæ of which are still folded closely along the midrib. As these leaves unfold they present a very characteristic appearance looking as if they had been cut by shears. Having reached the tender heart of the tree the beetles feed on it probably for some weeks, often destroying much or all of it, thus killing the tree.

The beetles swallow but little or none of the fiber through which they bore. A study of their mouthparts shows that they are less fitted for biting and chewing than they are for boring and tearing and crushing. The inner surfaces of the heavy mandibles do not meet except at the extreme base, the triangular space between them being filled by the maxillæ and the tip of the labium. The outer margins of the maxillæ and the labium are furnished with a dense fringe of rather long stiff bristles which, with similar bristles on the labrum, serve as a sieve for straining out the particles of plant tissue that are torn loose by the mandibles and the two tooth-like projections above them. The mandibles and their projections tear the tissue of the plant into shreds and the juice which is crushed from it is strained

through the bristles with which the mouth is surrounded. Examination of the alimentary canal of many beetles failed to show any of the plant fiber. The importance of this will be seen when we come to consider control measures.

The life history of this insect has not as yet been thoroughly worked out but in Samoa it probably takes it at least a year to complete its development. The eggs, which are laid in batches of ten to thirty, hatch in a very short time and the larvæ feed for several weeks, possibly for some months. In Samoa the larvæ are found most commonly in old decaying coconut logs or stumps, in places where these occur, but other rotting wood or decaying vegetable matter of any kind seems to furnish an abundance of food. The cacao pods that are often left in piles in the field furnish excellent breeding places. The larvæ are not commonly found in the living trees, but, if the crown is badly injured and contains much decaying matter, they may sometimes occur there.

One tree about twelve years old that, when standing, appeared to be only moderately injured was cut down and found to contain fifteen beetles, twenty-four larvæ, one third to one half grown, three smaller larvæ and a few eggs. A few larvæ and eggs were also found in other trees so that it is possible that, when the breeding places on the ground are not so readily available, more of the beetles will lay their eggs in the injured trees.

Unless a special search is made for them the pupæ are rarely seen and they are never found in any considerable numbers. Those that are found are usually in well-formed cells in portions of the log that are a little firmer than that in which the larvæ commonly work. Many of the larvæ probably enter the ground and pupate some distance below the surface. The pupal stage lasts for about ten days or two weeks. It is very difficult to rear the beetles from pupæ that have been taken from their cells. Not only are the pupæ very easily injured but they do not seem to be able to live except under the most favorable conditions. After the beetles issue they remain in the logs for a few days, waiting for the body wall to harden. Their flight is slow, heavy and, in the breeding cages at least, not very long sustained. In a cage 8 x 8 x 16 feet the longest flight noted was two and one half minutes. They probably would fly for a much longer time outside. They fly only at night, and sometimes come to lights, but even the brightest lights do not attract them in great enough numbers to be of any value in control work.

In Samoa many control measures have been tried. In the effort to protect the trees from attack, many substances which were supposed to act as repellants have been used. Our observations and experi-

ments seem to show that tar is the most effective of these, but even its use gives only a small measure of protection. Many planters simply painted the tar on the outside of the base of some of the leaves, but this soon became dry and hard and of little value. As kerosene was often added to the tar more or less damage to the tree often resulted and, in some cases, when equal parts of kerosene and tar were used, many trees were killed. As the kerosene adds little or nothing to the repellant value of the tar and as it is not needed for a thinner, there is no excuse for using it in this way. In experimenting with this material many young trees, ten to fifteen years old, were thoroughly cleaned by cutting out all the dead leaves, flower stems, etc., and then examining the tree carefully to see whether any beetles were already in it. Sometimes it was necessary to cut away some of the green leaves also before the beetles could be reached. A rather stiff wire with a hook or barb on the end of it was often found convenient for spearing the beetles and pulling them from their holes when they were deep in the tree. If the tree was badly infested with beetles it was often found necessary to remove nearly all of the old leaves before it could be thoroughly cleaned. After the beetles were removed all of the new-cut surfaces and the inner side of the base of the leaves were painted with tar, particular care being taken to treat thoroughly all of the holes and any open spaces where the beetles might enter. Alternate trees cleaned in the same way, but not treated with tar, and other trees from which few or none of the leaves were cut, were left as checks. An examination forty days later showed that the trees treated with the tar had fewer beetles in them than the check trees had, but the fact that many of the tarred trees were attacked by one or more beetles shows that this treatment offers only a small measure of relief.

Other trees were treated with lysol and some with lysol mixed with the tar, but as many of the leaves, especially the young leaves, were badly injured it was found that this substance could not be used for this purpose.

Coarse beach sand was poured into the crowns of a few trees, care being taken that plenty lodged at the bases of all of the leaves. Still other trees were treated in the same way with very fine sharp sand. When the trees were last examined only one had been attacked by the beetles, but not enough time had elapsed to make the experiment of any value. A little white arsenic was mixed with the sand in some of the trees. When such a mixture touched the young leaves they were usually more or less injured.

A few trees were dusted thoroughly with white arsenic, others with Paris green, still others were treated with these arsenicals mixed

in water. Such trees were covered with a netting under which a few beetles were placed. A few days later three beetles were found dead in the nets; three had bored into the trees and were apparently unaffected by the arsenic, but most of the beetles had escaped by tearing holes in the netting. In order that these arsenical sprays might be given a thorough test the crowns were cut from a few trees and the leaves all trimmed off. This part of the tree was very thoroughly treated, great care being taken that all exposed surfaces received some of the arsenic. They were then placed in a large cage where a few beetles were confined. Sometimes as many as four out of ten beetles would be found dead in the cage the next day, but many of the beetles entered the tree and were apparently unharmed by the presence of the arsenic. No tests were made to determine whether the dead beetles were killed by the arsenic. It was quite common to find some dead beetles in the cage even when the trees that were placed therein were not treated. The results of these experiments are such as we would expect after studying the mouth-parts and feeding habits of the beetle, for little or none of the arsenic would find its way into the stomach unless the leaf or stem fiber was swallowed.

In an effort to kill the beetles in the trees, without cutting the tree as much as was usually necessary, a little carbon bisulphide was poured into some of the holes after the mass of chewed-up fibres had been removed. The beetles were always quickly killed, but, unfortunately, the trees were always badly injured by the liquid and young trees were often killed.

During the last two years a long series of experiments have been made in an attempt to attract the beetles to various kinds of traps to lay their eggs. The trap very commonly used is made of pieces of rotting logs piled in a neat pile and partly covered with earth. Cacao pods, manure and other decaying vegetable matter adds to the efficiency of the trap. If no other breeding places are convenient the beetles may be attracted to these traps in considerable numbers. At regular intervals, usually every six or eight weeks, these traps are examined and the rotting logs split up and the beetles, larvæ and eggs found therein destroyed. If this work is carefully done it is quite effective on well-cleaned plantations, but it is expensive and requires close supervision. If the traps are made of small pieces of well-rotted wood, cacao pods or other decaying vegetable matter mixed with a little earth, the whole mass may be treated successfully with carbon bisulphide by pouring a little of the liquid in holes in various places over the trap. This will kill all of the beetles and larvæ except those

that are well protected in the wood. But this treatment is expensive and only successful when the traps are carefully made.

For the present at least then, the most effective method of control is to destroy the breeding places of the beetle. In an old well-kept plantation this is easily done, but on new plantations the problem is a very serious one, for, without very heavy expense, it takes a long time to burn or destroy all the old logs and stumps. Coconuts and often cacao trees are usually planted within one or two years after the bush land has been first cut over and while many of the larger trees are still lying unburned on the ground. As some of the bush trees are very hard they decay slowly and it is sometimes several years before they can be cut up or burned easily. As long as any of these decaying trees are in the field they are a constant menace to the surrounding coconut trees. Plantations near wild bush land have the dead trees there to contend with also.

Piles of cacao pods are favorite breeding places for the beetles, and when these are buried, as they often are in an effort to check the spread of the cacao canker, they become even more dangerous for the beetles readily find them and breed there in great numbers. The pods should be burned soon after they are opened unless some method of treating them can be found whereby they will not endanger the cacao trees or serve as breeding places for the beetle.

Realizing that it is impossible, because of lack of funds or labor, for some of the planters to clean up the land the local government has very wisely begun to aid them in this work. This is as it should be. This insect is a common foe and it is just as much the function of the government to protect its subjects from it as it is to protect them from invasion by another nation. The problem is largely a question of labor and will probably be satisfactorily solved only when the government can put enough men on the infested plantations to clean them as they should be.

Careful searching and breeding experiments have failed to reveal any insect parasite of this beetle in Samoa, nor is any such natural enemy known to occur in other countries. It is quite possible, however, that a careful search in places where the beetle has long been established may reveal some important enemies. Dr. Friederichs, zoölogist and plant pathologist for Samoa, has been working for some months with a fungus disease that is found attacking a very few of the larvæ on some of the plantations. Under laboratory conditions this can be made to do very good work but so far it has spread too slowly in the field to do very much good. It is possible that further experiments may teach us how to make this a valuable ally in our fight against this important pest.

RHINOCEROS BEETLE

1, *Oryctes rhinoceros* L.; 2, Larva of same; 3, Pupa of same; 4, Two larvæ of same that have been killed by a fungus.
(All natural size.)

1

2

3

4

1, Coconut trees affected by *Oryctes rhinoceros* L.; 2, Closer view of a badly affected tree. 3, Leaves cut by the beetle before unfolding; 4, Base of leaves injured by beetles.

REPORT ON A TRIP TO DEMERARA, TRINIDAD AND BARBADOS DURING THE WINTER OF 1913

By GEORGE N. WOLCOTT.[1]

Late in the autumn of 1912, I made a trip to Demerara, Trinidad, and Barbados to investigate certain aspects of the cane insect problems in those countries for the Porto Rican Board of Agriculture, and in the interest of the sugar planters of Porto Rico.

It would not have been possible for me unaided to have made observations of much value, had I not received the heartiest coöperation from various persons, particularly the Entomologists of the countries visited. Especial mention should be made of the assistance rendered by Mr. J. B. Harrison, Director of the Botanical Gardens, Mr. G. E. Bodkin, Government Economic Biologist and Mr. J. J. Quelch, Entomologist for the cane growers, of Demerara; Mr. F. W. Urich, Entomologist of the Board of Agriculture at Trinidad; Mr. J. R. Bovell, Director of the Local Department of Agriculture; Mr. Wm. Nowell, the Assistant Director, Entomologist and Mycologist, and Mr. H. A. Ballou, Entomologist of the Imperial Department of Agriculture for the Lesser Antilles, at Barbados.

The methods of growing cane, and the conditions of labor, soil and climate are different from those common in the southern United States. It will be necessary, therefore, to tell something of them before one can obtain an appreciation of the injury caused by the pests of cane and the effectiveness of the control measures adopted.

In Demerara, all the cultivated area in cane consists of a strip of land, varying in width from one to three or four miles, running along the coast—sometimes close to the ocean and only protected from it by the barriers, similar to the levees in Louisiana, which protect the fields from the overflow of the rivers, in other cases separated by miles of low marsh land from the sea. Although in recent years there has been a considerable consolidation of the estates, the typical cane estate consists of a narrow strip of land, sometimes only a quarter of a mile wide, which runs back from the ocean into the wild, uncultivated and often unexplored interior. The typical arrangement is a road extending from the mill back through the cultivated area, on one or both sides of which is the main canal or ditch—fifteen or twenty feet wide. Each ditch has numerous side branches at regular intervals, leading back between the fields. The estate is entirely dependent upon these ditches for the transportation of the cane from

[1] Published by permission of J. T. Crawley, Chairman of the Science Committee of the Board of Commissioners of Agriculture of Porto Rico.

the fields to the mill. After the cane is cut, it is placed in steel barges, which are towed along the canal and finally pass into the mill, where the cane is lifted by slings on to the carrier.

The cane is grown in beds about thirty feet wide. These beds are separated by small ditches one to two feet wide. The ditching is necessary as the soil is heavy and the drainage poor. The rows of cane usually run crosswise of the bed, but in some fields where the land is not quite so heavy and the drainage is consequently better, the rows of cane are lengthwise of the bed. This arrangement might permit of mechanical cultivation which is not possible where the cane is grown in short rows.

Labor is one of the most serious problems on the plantations as the native Indians will not work, the negroes are unreliable and it is only the indentured coolie labor from India that can be relied upon. These men must work for five years without remuneration, the only expense to the employer being the cost of the laborer's passage from India and his subsistence. During the next five years, the coolie receives the average market wage per day, minus one shilling (24c.) but must pay this shilling even on days that he does not work. At the end of ten years he is free to return to India, or move to town, or to any other estate. Coolies newly arrived from India can not be used for the hand control of insect pests because of their religious scruples, but boys of the second generation, born in the colony, prefer this work to any other.

In Trinidad the labor supply is much as in Demerara, as the coolies do most of the work, although sometimes natives and negroes are seen at work in the fields.

The cane in Trinidad is grown in a comparatively restricted area along the west coast between Port-of-Spain and San Fernando. The land is better drained, higher and of better texture than in Demerara. The cane is grown in level beds with the rows lengthwise of the bed, but despite the fact that the drainage ditches do not cut up the fields any more than in Louisiana, mechanical cultivation is seldom attempted.

The agricultural practice most noticeable is that of abandoning cane fields that are not producing a profitable tonnage. Even on the best managed and more profitable estates, one sees fields abandoned, growing up to weeds and grass, and pastured to oxen, with a few stalks of cane remaining to show what was the former crop. Upon the froghopper, *Tomaspis varia* Fabr., the most serious insect pest of cane in Trinidad, a bug that stunts or kills the cane by sucking the juice from the roots, is placed the blame for the abandonment of these fields. It is easy to see, however, that in an industry as un-

profitable as is sugar production at present in Trinidad, the tendency would be to cultivate only the more productive fields. How unfortunate and undesirable this practice is in connection with attempting to control the insect and fungus pests of cane will be discussed later.

In Barbados, the methods in vogue are the result of very cheap and abundant labor, the high price of land and the nature of the water supply. Everything is done on the most minute scale and by most antiquated and laborious methods. The island itself is small, and two thirds of the entire area is devoted to the cultivation of sugar cane. Modern factories are unknown and the cane is ground by small mills, which, in the majority of cases are driven by windmills. Most of the windmills are of the picturesque four-armed Dutch type. In some cases the rollers are vertical, although most of them are horizontal, and the cane is fed to the crushers by hand. The interior of the factory is very clean and sanitary, but everywhere manual labor is used instead of machines. Two men work the big ladle which transfers the juice from one evaporating pan to another and the concentrated juice is carried to the centrifugals in pails on the heads of negro women.

Another result of the cheap labor is that it is possible to cultivate the cane much better and cleaner than is done anywhere else. The entire absence of weeds is indeed remarkable and the more so when one considers that although the straight rows seem to invite mechanical cultivation, it is never attempted. The soil is black and of very good texture, but thin in most places. The coraline rock outcrops in many places and is never far beneath the soil. Rainfall in Barbados is comparatively slight and were it not for the coral rock, which acts as a sponge, conserving the rainfall and soaking up water from the sea, agriculture would be impossible. Capillarity brings the water up in to the soil from the surface of the rock and even in the dryest seasons the soil is moist at the depth of a foot. Soil moisture is further conserved by a thick mulch of cane trash, which is placed about all young plant cane. The wind often blows it away and it is carefully put back in place by the laborers.

From this short outline of the varying conditions under which cane is grown in Demerara, Trinidad and Barbados, it might well be expected to find a similar diversity in the insect pests affecting the cane. Such, in general, is the case. The cosmopolitan *Diatræa saccharalis* Fabr., however, occurs in all the countries and does more injury to the stalk than any other insect. *Pseudococcus calceolariæ* Mask., is also a common pest on cane, but its injury is not so generally considered serious.

In Demerara, the smaller moth borer, *Diatræa saccharalis* Fabr., and the closely allied species, *D. lineolata* Walker and *D. canella*

Hampson, are undoubtedly the most serious pests of cane. The importance of the smaller moth borer is recognized by the planters and managers, and most strenuous measures have been adopted for its control. On practically every estate there are gangs of boys, sometimes as many as fifty in a gang, who do nothing else the year round but cut out the dead hearts which have been caused in the young cane shoots by the *Diatræa* larvæ. The boys receive 6 cents per 100 for the larvæ and every effort is made to make the work thorough and systematic. There is a tacit understanding between the boys, however, that the collection of 700 is a fair day's work (and this represents more than a fair day's wage for a man) and they make no particular effort to collect more than about that number. It shows how serious the pest is, that the boys have no difficulty in collecting this number of larvæ day after day. The first impression one receives on going into a field of cane ready to be cut, is what an enormous amount of damaged cane is present. It is not at all difficult to find stalks with *Diatræa* holes and burrows in every internode, and it is practically impossible to find a single stalk of uninjured cane. For the ordinary varieties of cane this would mean that there would be practically nothing left worth grinding, but in Demerara, this problem has been met, though not solved, by the almost universal use of a local seedling cane, Demerara, 625. Although not highly resistant to *Diatræa*, it is more so than the older varieties and it is a valuable cane to plant for that reason, despite its low sucrose content.

The problem of controlling *Diatræa* is most seriously complicated in Demerara by the wet and dry seasons. There are always two and sometimes four wet seasons, and of course as many dry. Cane is cut towards the end of each dry season and seed cane will be planted at each wet season. As it takes from a year to eighteen months for the maturing of a crop, it can readily be seen that cane in all stages of growth is present on a single estate at all times. This means that there is always present, as partly or fully grown cane, a continuous and abundant source of re-infestation of the fields of young cane from which all the dead hearts have been cut out. Moths will fly out a hundred yards or more from the older cane, and more especially from cane that has been cut, depositing eggs on the young cane from which all the dead hearts have just been cut out, and in two or three weeks, the infestation will be as heavy as though no control had been attempted.

In addition to the attempted control of *Diatræa* by artificial means, the numbers of the pest are still further greatly reduced by parasites, four of which are present in Demerara. Two are parasites of the egg

and two of the larvæ. The cosmopolitan and ubiquitous *Trichogramma minutum* (*pretiosa*) Riley is everywhere abundant, and it is always easy to find egg clusters parasitized—indeed it is sometimes difficult to find clusters not parasitized. This high ratio of parasitism may be more apparent than real, as the black parasitized egg masses are very easily detected, but those not parasitized, being semi-transparent and light yellow in color, are much more difficult to see and not so many are collected. Another egg parasite, probably *Telenomus* sp., is also present in considerable numbers. A characteristic habit of *Telenomus* which makes it of much less value as a parasite, is that of neglecting to infest all the eggs in a cluster. Often as many as four or five eggs are thus allowed to hatch.

The adults of *Iphiaulax* sp., the braconid larval parasite, are quite noticeable in the field, as the red thorax and abdomen, very long black ovipositor and black and yellow wings make them conspicuous. The boys cutting out dead hearts often find six or seven larvæ or cocoons of this parasite in a day. This means almost exactly 1 per cent. of parasitism. Mr. Bodkin has also bred Tachinid flies from puparia which the boys had collected in dead hearts, but these are much less common than the *Iphiaulax*.

In addition to having the boys cut out dead hearts, they are also paid one half cent each for *Diatræa* egg mass that has not turned black or red, which are considered to be nonparasitized, but this practice is by no means general. Most managers are theoretically in favor of it, because it removes the insect before it has done any injury, but the practical impossibility of getting all, or even a large part of the clusters, makes it impractical except in connection with the cutting out of dead hearts. The cost of keeping large gangs in the field the year round is very considerable, for the boys who cut out the dead hearts have work throughout the year as it takes three or four weeks to go over an estate thoroughly and they immediately recommence. It is difficult to say whether the cutting out of dead hearts does control *Diatræa* in a measure or not, but one is safe in saying that *Diatræa* injury would be much more severe, were it not done. It certainly is true that to be effective, it must be well done, and when negro women and girls are used instead of the coolie boys, the value of their work is problematical, for in addition to failing to cut out all the dead hearts, the women also cut perfectly healthy shoots.[1]

[1] The coolie boys, far from being so stupid as to cut healthy shoots, are so bright that they have been known to substitute the larvæ of wasps for the *Diatræa* larvæ, which they somewhat resemble in general appearance and are, of course, much more easy to obtain in large numbers. The unsuspecting overseers, who look over what the boys have collected, are none too observant, and often the deception passes.

I wish to emphasize the fact that *Diatræa* is *NOT* controlled in Demerara, by the two egg parasites, *Trichogramma* and *Telenomus*, the larval parasites, the cutting out of dead hearts, the collecting of nonparasitized egg masses, clean cultivation, the burning or not burning of trash, all combined.

Mr. J. J. Quelch, the Entomologist for the planters, tells me that the one measure that can be adopted which will in part make up for the lack in Demerara of a season when no partially grown or large cane is present as a source of re-infestation of the young cane, is the simultaneous planting of enormous blocks of cane. It is the indiscriminate scattering of the fields of all ages of cane on an estate that makes possible the rapid and easy infestation of young cane. *Diatræa* moths are not long distance flyers and when all young cane is in a large block away from the older cane, it will not be so readily infested. This is undoubtedly a very ambitious plan of campaign against the smaller moth borer, but the amount and seriousness of the injury and the comparative ineffectiveness of the methods of control, now used, make radical measures necessary.

The only other serious pest of cane in Demerara is the giant moth borer, *Castnia licus* Fabr. Several years ago the injury caused by this pest was very great, but the systematic warfare commenced against it has lessened its numbers to such an extent that its depredations are now of somewhat minor importance. The eggs of the moth are deposited in the earth or in trash on the ground. The young larva enters the cane at the surface of the ground and burrows down into the root and also up into the stalk. The larvæ grow to be four inches or more in length and half an inch in diameter. It may well be imagined how serious is the injury that one larva does to a stalk of cane. When the cane is young one individual will often kill several stalks and one can readily see the injury in the field even before the cane is cut. Older cane, however, is not killed by *Castnia*, for the larva eats only the sweet pithy inside of the lower portions of the cane, and the growth at the tip is not appreciably checked. It is only when the cane is cut that one can accurately determine the extent of the injury, as then the large holes in the stubble are most noticeable, or by watching the cane in the cane cars the amount of infestation is easily estimated.

Despite the large amount of injury the giant moth borer is capable of producing, it is an indication of poor estate management if it is allowed to cause serious trouble, as there are several entirely practical measures of control. A measure that naturally suggests itself is the capture of the adults. These big day-flying moths are a common sight in the cane fields, being most abundant on bright days between ten

in the morning and noon. They are usually seen in the fields of young ratoon cane, where the eggs may be deposited. No baits seem to have any particular attraction for them, but the moths are not particularly difficult to catch on the wing. Gangs of boys, armed with home-made butterfly nets patrol the fields of young ratoon cane and have little difficulty in capturing fifty or seventy-five in a day.

In young cane, where the stalk is not large, the entire shoot is killed by *Castnia*, the larva retreating into the stool and going into another shoot to complete its development. In fields of young cane, the boys going through, cutting out the dead hearts caused by *Diatræa*, are also able at the same time to cut out the shoots injured by *Castnia* and capture the larva inside. Three years ago, and more, when *Castnia* was a much more serious pest than it is now, the price set for the larvæ was one cent each. The amount of money the boys were able to earn by cutting out giant borer larvæ was so great that the insect received the name of "gold-digger." Another opportunity the boys have of collecting the "gold-digger" is after the cane is cut for the mill, when the conspicuous black hole in the stubble of the cane shows where a fully grown larva is hidden in the stool below. Very few larvæ are ever found in the cut stalks, as the larva retreats into the stool when it becomes aware of the approach of the cane cutter. The tunnels are considerably larger in proportion to the size of the insect than are those of the smaller moth borer and the insect can move in them more quickly.

Mr. J. J. Quelch told me of fields where *Castnia* injury had been particularly severe and wholesale methods of destruction had been necessary. After the cane was cut, the field was flooded for several weeks entirely killing out all *Castnia* larvæ and pupæ present in the stools.

Three years ago the injury by the giant moth borer to cane all over Demerara became so severe that strenuous measures had to be adopted. It was at this time that the four control measures above described were tested out and found to be thoroughly practical and satisfactory. They are as follows:

(1) Collecting of the adult moths in butterfly nets.

(2) Cutting out the young larvæ in the young ratoon cane.

(3) Cutting out the older larvæ and pupæ from the stools of cane after the crop has been harvested.

(4) In the case of very heavy infestation, the flooding of the entire field after the cane is cut.

The control thus obtained is not permanent and is maintained only by the persistent enforcement of these regulations, even at times when *Castnia* has become comparatively scarce. No outbreak need

be feared so long as the collection is kept up, and even should *Castnia* become abundant again, there would be no cause for alarm, as the measures of control are well known and their effectiveness has been demonstrated.

When one enters a field where the cane is soon to be cut, his first impression is of the enormous amount of cane that has been seriously injured by *Diatræa*. This primary injury by *Diatræa* is sufficiently important in itself, but in addition there is the secondary infestation by other insects that only enter cane that has been previously injured by something else. . . . All stages of the weevil stalk borer, *Metamasius hemipterus* Linn., are to be found in the greatest abundance. If this pest were able to reproduce rapidly and survive adverse conditions, the injury it might produce would be very great, but nowhere was it observed to cause nearly so much injury as *Diatræa*.

Much cane is also injured by termites, or "wood ants" as they are called by the planters. They never attack sound cane, but as all the cane in Demerara is infested with *Diatræa*, the termites have no difficulty in finding a place of entrance to the interior of the stalk. They hollow out the stalk so completely that only a thin shell remains, which easily breaks through when grasped in the hand. The termites use the cane stalks as a source of food and building material, and as a living place. They also build many galleried nests, the individual walls of which are thin as cardboard and break through readily, but the nest will not break into large pieces even when subjected to rough treatment. It is a common practice to carry these nests from the field when the cane has been cut, and burn them on the towpaths at the edge of the field. This control measure seems to be quite effective, although the danger of gravid females dropping from the nest while it is being carried across the field, is quite serious. The nests undoubtedly should be carried in a bag or on a tray.

The sugar-cane mealy bug, *Pseudococcus calceolariæ* Mask. was moderately abundant in most fields. As compared with the injury caused by *Diatræa* and *Castnia*, the mealy bug is not considered a serious pest. Its numbers are kept in check somewhat by a predaceous lady beetle, the name of which has not been determined.

The final impression one carries away with him of the cane insect problem in Demerara concerns chiefly the following points:

(1) The enormous and wide-spread injury by the smaller moth borer, which despite all control measures now being used against it and the natural control by the various parasites, seems to be holding its own and is most decidedly not less abundant than it was at any time in the past.

(2) The serious injury by the giant moth borer, which is being controlled and is much less abundant than formerly, and

(3) The comparative insignificance of the injury by the other minor cane pests, *Metamasius*, termites and the mealy bug, which despite its intrinsic importance, seems almost negligible by comparison with the injury by *Diatræa*.

In Trinidad, the situation in regard to the insect pests of cane is unique. The most injurious pest is not *Diatræa*, as it is in practically all other sugar producing countries of the West Indies, but a froghopper. Insignificant as is the injury produced by froghoppers elsewhere, in Trinidad the froghopper has achieved as much notoriety as a pest of cane as has the boll weevil in the United States. The sugar cane froghopper of Trinidad, *Tomaspis varia* Fabr., is a small bug, that passes its immature stages as a nymph underground feeding on the roots of cane, grass and weeds. The adult is one quarter to one half inch long, with blue-black wings banded with yellow, folded over its back. It sucks juice from the leaves and stalk of cane, but produces no serious injury. The eggs are laid in the trash and sometimes in the ground, from which the newly-hatched larvæ have no difficulty in reaching the roots of the cane. Despite the insignificant size of the nymphs, the enormous numbers in which they appear on the roots of the cane, especially if they chance to be abundant during a dry spell when the cane is young, either kills the cane outright, or so stunts the growth, that the crop is worthless and in many cases the field is abandoned.

It is not at all surprising that *Tomaspis* should be a pest on cane in Trinidad when one considers the agricultural field practices most common there. What an unprejudiced observer first notices is the great abundance of weeds in the fields of cane. Grass and weeds are alternate host plants, if they are not the original hosts of *Tomaspis*, and as they are allowed to grow almost unchecked in the cane fields, it is not surprising that the froghoppers have also attacked the cane. Another most noticeable feature of Trinidad agriculture is the large number of abandoned fields, where a few stools of cane still remain, but are mostly grown up to grass and weeds. The roads and "traces" through the cane estates and the land along the railroads are overgrown with weeds. The whole environment is ideal and could not be better for the propagation of large numbers of froghoppers and other pests of cane. When the managers of the estates come to realize the importance of cleaning up the grass and weeds in the cane fields and of planting some other crop in the abandoned fields, there will be a most noticeable reduction in the injury to cane by insects, and more particularly in the injury caused by the froghopper. Because of the

lack of sanitation in the fields, the froghopper is a difficult pest to control and is rendered all the more difficult because of the lack of vulnerable places in its life history.

The nymphs are found only on the roots of cane, where no insecticide can reach them. The adults are of such small size and are so active, that their collection by boys is impracticable. It might be possible to reduce their numbers by burning the trash in which their eggs are deposited, but as the eggs are also deposited in the ground and it is usually in the moister trash which is closest to the ground and most difficult to burn, that most of the eggs are deposited, this practice would only destroy much-needed humus, and leave the major portion of the eggs undestroyed. As all ordinary methods of control are impracticable, a most novel and unusual plan of campaign has been adopted.

The fungus, *Metarrhizium anisopliæ* Sorokin, produces a fatal disease of froghoppers and other insects called the Green Muscardine. When the fungus spores are widely diffused throughout a cane field, a heavy mortality of the froghoppers follows, if the moisture and temperature conditions are favorable. At the beginning of the rainy season, when the froghoppers begin to become most abundant, the conditions for the growth and development of the fungus are ideal. Although attempts to use fungus diseases in combating insects have been made elsewhere, never before has the growth of large amounts of fungus spores and their thorough distribution throughout a field to kill the insect pests of the crop growing there been attempted on so large a scale. The spores of *Metarrhizium* are grown on layers of cooked rice spread out on trays three feet square, ten of which trays are contained in a culture cabinet. As about 70 pounds of the mixture of spores with the proper amount of cassava starch for field dusting are produced from one cabinet; on several estates in Trinidad as many as four of these cabinets are in operation, and as the length of time for the maximum production of spores is only three weeks, it is apparent that the commercial production of spores has been made practical. The application of spores in the field is made from a blower mounted on a railroad flat car. The pioneer work in the devising of large-scale, commercially practical methods of growth and application of fungus spores has been done by Mr. J. B. Rorer, Pathologist of the Trinidad Board of Agriculture. To his recent article in "Phytopathology," April, 1913, pp. 88–92, one may be referred for the details of the work.

The practical results of this field dusting are somewhat inconclusive, as few of the cabinets were put into operation till towards the end of the rainy season last year, and most of the dusting has been done during the dry season when conditions are not optimum for the pro-

duction of an epidemic of the Green Muscardine disease among froghoppers. Mr. Urich assured me, however, that in the one examination he made where spores had been applied early, at least 95 per cent. of the nymphs in the stool of cane were found dead and covered with the characteristic olive green spore masses of *Metarrhizium*.

Most of the planters seem to be convinced of the desirability of using this fungus for the control of the froghopper, and on most of the estates of the island cabinets for growing the spores were seen. Mr. Connell has already dusted with the spores over 500 acres of cane land at Esperanza estate, and at other larger estates it is planned to dust similar areas. It will be with much interest that the outcome of this most extensive spore dusting during the coming wet season will be watched.

In addition to the work with the Green Muscardine, a diligent search has been made for predators and parasites. In the fall of 1911, Mr. Urich went to Mexico, where *Tomaspis postica* Walker, does considerable injury to cane, and he imported from there a Reduviid bug, *Castolus plagiaticollis*, which is a very efficient predator on the adult froghoppers. . . . From grass collected in the moist valleys and ravines in the northern part of Trinidad, two Chalcidid parasites have been bred by Mr. P. L. Guppy, Mr. Urich's assistant. One of these is a brilliant vermillion color and the other a light brown. Neither has yet been bred in large numbers, and it is doubtful if they will be of economic importance. That they already occur in the island, and in localities not more than a few miles from cane fields heavily infested with froghoppers, indicates that unless some very successful method of artificial propagation is devised they will never be of much practical value, although interesting from a scientific standpoint.

On all cane estates in Trinidad, the injury by *Castnia licus*, the giant moth borer, is most noticeable. Indeed, from what superficial observations I was able to make, it seemed to be more common than in Demerara. Its numbers are becoming less each year in Demerara, but in Trinidad, the pest is rapidly becoming more abundant, as Mr. Urich informed me that on only a few estates were control measures attempted. It is impracticable to flood the fields from which cane has recently been cut, no attempt is made to collect the full-grown larvæ and pupæ from the stools of cane, and the young larvæ are not cut out of young cane, but most energetic measures are used for the collection of adults by gangs of boys with butterfly nets. That this method of control is successful if continued over a series of years, is shown by the figures given below, showing the number of adults collected on one estate.

CASTNIA ADULTS COLLECTED ON ONE ESTATE

Year	1909	1910	1911	1912
No.	182,734	116,707	89,708	52,271

Approximately the same number of boys was employed in the collection each year and the figures are therefore comparable. If the collecting of adults for four years produced a decrease of over 70 per cent. in the numbers of the pest, it may be more easily realized how much better *Castnia* is kept under control in Demerara where additional measures are used.

Although cane infested with the smaller moth borer is common in Trinidad, the injury by this species is not serious as compared with that produced by the froghopper. Although much more common than *Castnia*, the total amount of injury produced by *Diatræa* is not so great. Nothing in the way of control is attempted on any estate. None of the managers have sufficiently realized the loss caused by *Diatræa* to seriously attempt to control it. This is not particularly surprising as the *Diatræa* larvæ are abundant only during the beginning of the rainy season, May and June, but after this they are comparatively scarce. Ordinarily the smaller moth borer does not cause much dead heart, as the larvæ do not become abundant until after the cane has advanced beyond the earlier stages of growth. In that portion of the cane stalk between three inches and a foot from the ground occurs about 90 per cent. of all the injury that one sees on cane brought to the mill. This was especially noticeable at the Usine Ste. Madeleine. Whether any other factors than rainfall and abundance of parasites enter into this sudden appearance and practical disappearance of *Diatræa* has not yet been worked out. The egg parasite *Trichogramma minutum* (*pretiosa*) Riley, is quite common and the brilliantly marked braconid parasites of the larvæ are abundant in the fields. Three of them were seen hovering over the cane on the cane carriers of the Usine. They were not feeding on the juice from the cut ends, but rather were examining the *Diatræa* holes.

Among the more important minor pests of cane in Trinidad are the weevil stalk borer, *Metamasius hemipterus* Linn., var. *decoloratus* Gyllh., the "gru-gru" worm, *Ryncophorus palmarum* Linn., and the sugar-cane mealy bug, *Pseudococcus calceolariæ* Mask. The latter is moderately abundant on most cane, but appears to do but little serious injury. It is attacked by the larva of a predaceous lady beetle, which is present where the mealy bugs are most abundant. The injury by the "gru-gru" worm is mostly confined to seed-cane that has not been properly treated with Bordeaux mixture. The weevil stalk borer is quite common but never so abundant as to do serious damage. In some of the cane brought in to the Orange Grove mill by coolie cane farmers, a few stalks were noticed which had been almost entirely destroyed by termites. While looking over

some of these specimens of its injury in the laboratory, Mr. Urich found a scale insect abundant in the tunnels of the termites.

Although in most respects Barbados is strange and different from Trinidad and Demerara, most of the insect pests are anything but unfamiliar. True, the larger moth borer is not found, nor the frog-hopper, but the small, stunted, untrashed canes contain an enormous amount of *Diatræa* injury. Both kinds of the sugar-cane mealy bugs, *Pseudococcus calceolariæ* Mask., and *P. sacchari* Ckll., are abundant and with them are almost invariably found the larvæ of a lady beetle. At the time I was there, the sooty mold on the leaves caused by fungous growths on the honey dew secreted by the sugar-cane leaf-hopper, *Delphax saccharivora* Westw., and the fluffy white masses indicating the position of the egg-masses in the leaves, were most noticeable. The weevil stalk borer, *Metamasius hemipterus* Linn., is also abundant, as thirty larvæ were taken from a single stalk of cane.

With the exception of *Diatræa* all these are minor pests in comparison with the injury produced by the weevil root borer, *Diaprepes abbreviatus* Linn. This is by far the most serious pest here. One can pull up with but slight exertion half-grown stalks of cane, which have been stunted and, in most instances, killed by it. The injury caused by this weevil in Barbados is more serious than that due to *Lachnosterna* grubs in Porto Rico, as the stalks are attacked when only half-grown. Many of the small roots are eaten and the center chewed out of the main tap root of the cane. It is very seldom that the cane plant has sufficient roots left to make any new growth after the grubs have destroyed the tap root, and the plant is then practically dead. When the ground around the stool is dug over, several grubs are found at a depth of one to three feet. When the cane crop is removed from the field, the partly grown grubs do not die, but burrow down to a depth of several feet where they await the planting of the next crop. Mr. Nowell had a grub remain alive for over ten months in a cell of earth in a petri-dish kept in the laboratory, and the grub seemed as healthy and active at the end of that time as when first dug up. . . . No effective method of control is known, but the numbers of the grubs can be considerably reduced by hand picking of the adults. The adult weevils collect in large numbers on corn and sorghum to feed, and there they may be readily captured by boys.

The injury by *Diatræa* in Barbados seems all the more severe because those varieties of cane are grown which have a small stalk and a high percentage of sugar. Although there were probably not so many tunnels in a single stalk as in Demerara, the total amount of injury to the cane seemed to be greater. It was stated that injury by *Diatræa* had been particularly severe this year, but it must be considerable

every year. Mr. Bovell stated that field experiments had shown that cutting out the dead hearts in the young cane caused so much injury by root disease that more sugar was obtained from the untreated cane. The greater part of the injury from *Diatræa* occurs in the upper portion of the stalk and possibly this is another reason why the cutting out of dead hearts was not more successful. *Trichogramma minutum* is the only parasite of *Diatræa* in Barbados.

The most interesting and important insect pest of cane in Barbados from the standpoint of one interested in its parasitism and more particularly the introduction of that parasite into Porto Rico, is the brown hard-back, *Phytalus smithi* Arrow. The genus *Phytalus* is closely related to the genus *Lachnosterna*, the grubs of which genus are so injurious to cane and other plants in southern Porto Rico. The grubs of *Phytalus smithi* never attain to more than half the size of the Porto Rican *Lachnosterna* and they are never sufficiently abundant to cause serious injury to the cane. The reason why they do not become an important pest is probably because they are parasitized by a black wasp, *Tiphia parallela* Smith.

A few years ago in the Island of Mauritius, the cane was attacked by a root grub and in certain parts of the island it caused an entire failure of the cane crop. The adults of this grub were described as new by Mr. Arrow of the British Museum under the name *Phytalus smithi*. A short time later, when Mr. Guy S. Marshall was looking over a collection of local cane pests in Barbados, he noticed beetles similar to the adults of the grub which was such a pest in Mauritius[1] and he decided they were of the same species. It was then remembered that a considerable time ago new cane varieties had been sent from Barbados to Mauritius. The usual method of introduction was to send a few joints of a stalk of cane with the ends sealed and packed in moist sawdust or charcoal, but some varieties had been introduced by sending an entire stool of cane in a pot of soil. It is quite probable that the grubs of *Phytalus smithi* were introduced into Mauritius in the soil surrounding the roots of these new varieties of cane. The parasite *Tiphia parallela* was not introduced with the grubs, and with the parasite not present to check its increase, *Phytalus smithi* became a serious pest. Although most strenuous measures of hand picking the grubs and collecting the adults have been adopted in Mauritius in the hope of entirely exterminating the beetle (for it is a pest in only a comparatively small portion of the island at present), it seemed very desirable to introduce the parasite *Tiphia parallela* to aid in its control. Under the direction of Mr. J. R. Bovell in

[1] Mauritius is a small island in the Indian Ocean, southeast of Africa.

Barbados, a large number of *Tiphia* cocoons are being gathered and these will be sent to Mauritius in cold storage. Spencer's plantation, Christ church, where the cocoons were being dug up, was visited. Mr. A. A. Evelyn, the manager, had five or seven men at work digging to a depth of two and sometimes three feet around the edge of the cane fields, where the grubs of *Phytalus smithi* were most abundant. Judging by the results of my own work in Illinois, they were having only moderate success, as on many days they would discover nothing, although sometimes they would get a dozen or more cocoons in a few hours. As the shipment of cocoons was soon to be despatched to Mauritius, arrangements were made with Mr. Evelyn to continue the work of digging the cocoons of *Tiphia parallela* that some might be sent to Portp Rico and an attempt made to establish the species as a parasite of the smaller species of native *Lachnosterna*.

NOTES ON PODABRUS PRUINOSUS

By H. F. Wilson, *Entomologist, Oregon Agricultural College, Corvallis, Ore.*

During the past two years this insect has been very abundant in the Willamette Valley and is one of the most important agencies in the control of all forms of plant lice.

The three principal species held in check by this pest are the rosy apple aphis (*Aphis sorbi* Kalt?), the black cherry aphis (*Myzus cerasi* Fab.), and the vetch aphis (*Macrosiphum pisi* Kalt?).

The adults begin to appear about the first of May and by June first are very abundant. By July first, only a few individuals can be found. During the warm days along about the first of June the beetles are flying about everywhere, apparently in search of food. They are also quite commonly found in the vetch fields and in the rolls of infested apple and cherry leaves.

They undoubtedly destroy many aphids in a day and are of great economic value. The manner of devouring an individual aphis resembles very much that of a hungry dog with a piece of fresh meat and several companions watching the operation. The aphid is not exactly eaten, as the beetle crushes it with the mandibles and extracts the juices. The remains are then cast to one side and another morsel is sought for.

When disturbed the beetles try to escape from the folds of the leaves and, if resting or crawling on the leaf, will quickly drop to the ground.

FIGURE 11. *Podabrus pruinosus*; *a*, Mass of Eggs; *b*, Larva; *c*, Pupa; *d*, Adult (Original).

The Various Stages

The *eggs* were not observed in the field but in the insectary they were deposited on top of the ground in masses as shown in figure 11 *a*.

The individual egg is light yellow in color, oblong in shape and measures .36 mm. in length.

The *larvæ* (Fig. 11 *b*) are found in the ground from three to six inches below the surface and when mature measure from 15 mm. to 20 mm. in length. They are pink in color and are covered with numerous fine hairs which give them a velvety appearance. The three thoracic segments have two longitudinal dark markings on the dorsum.

The *pupæ* (Fig. 11 *c*) are found in earthen cells in the moist earth. When the pupal stage is first formed they are white; later they change to pink and as the elytra and appendages develop, they change to a dark blue; the eyes are red; abdomen above and below covered with numerous fine hairs that give them a velvety appearance. Dorsum of prothorax also covered with these hairs. The prothorax above square and shaped as in the adult.

The *adults* (Fig. 11 *d*) are dark blue in color with the prothorax, front part of the head and tip of abdomen light brown. First three segments of the antennæ brownish, shaded with black. Segments following, black with a small amount of brown at the base. Legs black, shaded with brown.

Upper and lower side of abdomen covered with fine light gray hairs. Length of body 10 to 14 mm.

THE GEOGRAPHICAL DISTRIBUTION OF THE STABLE FLY, STOMOXYS CALCITRANS[1]

By Charles T. Brues

The common stable fly, *Stomoxys calcitrans* L., has recently received considerable attention at the hands of entomologists, medical men and veterinarians. It is a nearly cosmopolitan phlebotomic Muscid that has long been a serious pest of domesticated animals and an occasional nuisance to human beings on account of its blood sucking habits. For some time it has been known to act as an occasional carrier for the bacillus of anthrax. More recently it has been shown to be capable of acting as a vector for the virus of acute epidemic

[1]Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 69.

poliomyelitis (infantile paralysis) [1] and it is also quite probably a regular or accidental carrier of other human and animal diseases with which its connection has not yet been elucidated.

On account of its importance as an economic insect, it has seemed worth while to publish the following resumé of the distribution of *Stomoxys calcitrans* in different parts of the world. The material here presented has been gathered from many sources; much has been collected from published writings, but a great part has been supplied by entomologists in various parts of the world to whom requests for information were sent. As is evident from the context, the writer is greatly indebted to these gentlemen who have so freely given data from their personal experience.

Next to the common house fly, latterly termed the typhoid fly, this species is one of the most widely diffused species of insects, and has been found in some part of nearly every habitable region of the globe. Like the house fly, it is probably a native of the Old World, most likely of central Europe, and if not actually native to North America, it was evidently brought hither on ships at an early date.

The species was named *Conops calcitrans* by Linnæus in the tenth edition of his Systema Naturæ (p. 604; 2) and soon afterwards Geoffroy [2] erected the genus *Stomoxys* to include this species which was the only one then known. I have not been able to approximate the date of its introduction into America, but its abundance in Philadelphia as early as 1776 is attested by the following excerpt from an account written by Thomas Jefferson.[3] In describing the reasons for the hasty adoption of the American Declaration of Independence by the Continental Congress on July 4th, 1776, Jefferson writes:

"The weather was oppressively warm, and the room occupied by the deputies was hard by a stable, whence the hungry flies swarmed thick and fierce, alighting on their legs and biting hard through their thin silk stockings. Treason was preferable to discomfort."

No entomologist, after reading this paragraph, can question the fact that the "hungry flies" were anything but *Stomoxys calcitrans*, so characteristic is Jefferson's account.

That it was present in the United States in the early colonial days is thus certain. One should expect as much, however, for it is adapted

---

[1] Brues, C. T. The Relation of the Stable Fly (*Stomoxys calcitrans*) to the Transmission of Infantile Paralysis. Journ. Econ. Entom., Vol. 6, pp. 101–109 (April, 1913).

[2] Histoire Abregée des Insectes, II, 538 (1762, 1764, 1799).

[3] For this interesting information I am indebted to an article by Hubert Bruce Fuller, entitled "Myths of American History," which appeared in Munsey's Magazine for May, 1913.

to maintain its existence for long periods on shipboard, and is undoubtedly thus carried for long distances. From the following data recently given me in a letter by Dr. H. H. P. Severin, it will be seen that at the present time the species is readily transported by ships, and conditions in the past must have been still more favorable for its existence under such circumstances. Dr. Severin writes: "In making the trip from San Francisco to Honolulu, the boat on which I was traveling carried about fifteen mules and horses which were placed in temporary stalls on the lower deck of the steamer. These stalls were crudely constructed, consisting of but little more than the roof, and yet during the seven days of the trip, I noticed stable flies pestering these animals."[1] Such adaptability on the part of *Stomoxys calcitrans* undoubtedly accounts for the ease with which it has become disseminated so widely, and it seems strange that other members of the same genus have not followed it generally in its migrations.

Together with a number of related genera, all of old-world origin, *Stomoxys* is usually regarded as forming the subfamily *Stomoxydinæ* of the family Muscidæ. All of these genera are sharply differentiated from other Muscidæ by the piercing mouthparts and phlebotomic habits of the imago. At the present time, some seven genera have been recognized.

1. *Glossina* Wiedemann.
2. *Lyperosia* Rondani.
3. *Hæmatobosca* Bezzi.
4. *Hæmatobia* Robineau-Desvoidy-*Siphona* Meigen?).
5. *Stygeromyia* Austen.
6. *Stomoxys* Geoffroy.
7. *Philæmatomyia* Austen.
8. *Glossinella* Grünberg.

Of *Stomoxys* a large number of species have been described, some thirty-one of which appear to be well founded. Thirteen of these were listed by Bezzi[2] in 1907, and the remainder have since been distinguished.

1. *bengalensis* Picard. Bull. Soc. Ent. France. 20: p. 21 (1908). India.
2. *bilineata* Grünberg. Zoöl. Anz. 30: p. 89 (1906). East Africa.
3. *boneti* Roubaud. Bull. Soc. Path. Exot. 4: p. 124 (1911). Dahomey.
4. *bouffardi* Picard. Bull. Soc. Ent. France, 1907, p. 27. Sudan.

[1] Since Dr. Severin's communication was received, the writer has had the opportunity to observe the same conditions on steamers that carry horses and cattle, plying on the western coast of South America between ports in Panama, Ecuador and Peru.

[2] Mosche Ematofaghe. Rend. R. Ist. Lomb. Sci. and Lett., II: 40 (1907).

5. *brunnipes* Grünberg *ibid.*, l. c. Camerun; Eritrea.
6. *calcitrans* Linné Syst. Nat. 10; 604. 2 (1758). Distribution discussed below.
7. *dacnusa* Speiser. Zoöl. Anz. 33: p. 667 (1908). Annam.
8. *glauca* Grünberg *ibid.*, 30: p. 88 (1906). Camerun; Togo.
9. *griseicepe* Becker. Mitt. Zoöl. Mus. Berlin, 4: p. 195 (1908). Madeira.
10. *hovas* Brauer. SB. Akad. Wien, 108: p. 517 (1899). Madagascar.
11. *indica* Picard. Bull. Soc. Ent. France, 20: p. 20 (1908). India.
12. *inornata* Grünberg. Zoöl. Anz. 30: p. 90 (1906). Camerun.
13. *lafouti* Picard. Bull. Soc. Ent. France, 1907, p. 28. Mauritius.
14. *libatrix* Robineau-Desvoidy. Myod. p. 387 (1830). Southeastern India.
15. *limbata* Austen. Ann. Mag. Nat. Hist. (8) 3: p. 292 (1909). India.
16. *nebulosa* Fabricius. Syst. Antl. p. 282 (1805). (*calcitrans* Linn.?). South America.
17. *nigra* Macquart. Mem. Soc. Sci. Lille, 1850, p. 212. Natal; Mauritius.
18. *oblongopunctata* Brunetti. Rec. Indian Mus. 4: p. 73 (1910). India.
19. *ochrosoma* Speiser. Sjöstedt's Kilimandjaro-Meru Exped. 10–5 : p. 162 (1910). German East Africa.
20. *omega* Newstead. Ann. Trop. Med. & Paras. 1: p. 87 (1907). West Africa.
21. *pallida* Roubaud. Bull. Soc. Path. Exot. 4: p. 125 (1911).
22. *plurinotata* Bigot. Bull. Soc. Zoöl. France, 12: p. 593 (1887). Ceylon.
23. *pratti* Summers. Ann. Mag. Nat. Hist. 8: p. 238 (1911). Straits Settlements.
24. *pulla* Austen. Ann. Mag. Nat. Hist. (8) 3: p. 294 (1909). India.
25. *pusilla* Austen *ibid.*, t. c.: p. 293 (1909). India.
26. *sellata* Grünberg. Zoöl. Anz. 30 : p. 90 (1906). Kamerun.
27. *sexvittata* Roubaud. Bull. Soc. Path. Exot. 4: p. 396 (1911). Sudan.
28. *sitiens* Rondani. Ann. Mus. Civ. Genoa, 4: p. 288 (1873). Eastern Africa.
29. *taeniata* Bigot. Bull. Soc. Zoöl. France, 12: p. 594 (1887). Port Natal.
30. *triangularis* Brunetti. Rec. Indian Mus., 4: p. 77 (1910). India.
31. *varipes* Bezzi. Rendic. Ist. Lomb. (2) 40: p. 446 (1907). Eritraea.

The following citations of localities for *Stomoxys calcitrans* is undoubtedly by no means complete, particularly since this species has been incidentally referred to a great many times in the literature of economic entomology and also frequently in miscellaneous publications of various kinds. Even in the United States where it probably occurs commonly in every state, published records are scanty and many of the localities here cited have been kindly furnished by entomologists from their personal experience. In the same way a number of foreign entomologists have supplied similar data, and to all I am greatly indebted for their uniformly courteous attention to my requests for information.

United States of America

Arizona.—Mr. F. C. Bishop has recently written me that he heard through Dr. Morrill of Phoenix, Ariz., that the stable fly is, so far as he has observed, rather rare in that state. Dr. Morrill has seen the species resting in considerable numbers on his house in Phoenix, but never noticed them in abundance around dairies.

California.—Mr. C. H. Richardson, Jr. informs me that the stable

fly is very common in southern California where it is a serious pest to cattle, and Professor Doane writes that he has found the larvæ breeding very commonly in cow manure around dairy barns in the vicinity of Stanford University. Herms [1] mentions it as a household insect in California.

Colorado.—Bishopp [2] quotes from Prof. Gillette the statement that this species is possibly the worst pest of livestock in Colorado on account of its being so abundant and ever present.

Professor Cockerell writes that it is abundant at Boulder, Colo. and that one of his students, Mr. Tucker, found it at Tabernash.

District of Columbia.—Howard [3] who has studied this insect rather extensively in Washington, D. C., refers to its abundance there in late summer.

Connecticut.—The stable fly is widely distributed throughout Connecticut, apparently in about the same abundance as has been observed in Massachusetts. The writer has seen it especially abundant along the Connecticut Valley in late summer.

Florida.—The writer has seen the stable fly in the northeastern part of Florida, but it does not appear to be nearly so common there as in the northern states. Johnson [4] records it from St. Augustine and Lake Worth, and Bishopp [5] states that investigations made in Central Florida indicate that it is seldom of importance as a pest in that section.

Georgia.—According to Bishopp [6] the stable fly is a pest of more or less importance in the grain belt of this state every year.

Mr. C. W. Johnson also informs me that he has specimens in his collection, collected by Pilate at Tifton, Ga.

Illinois.—The stable fly is abundant about Chicago and many parts of northern Illinois, according to the experience of the writer.

Prof. A. D. MacGillivray, in a letter, has offered the following note concerning its occurrence in the northern central portion of the state near Urbana: "In the two years that I have been here, this insect has been quite abundant. The flies come into the laboratory and bite us on the shins so as to almost drive us out in the afternoons. Last September there was a great reduction in the amount of milk produced in this region, and the dairies all reported a great abundance of flies, which of course meant the stable fly."

---

[1] Bull. Agric. Expt. Sta., California, No. 215, p. 517 (1911).
[2] Journ. Econ. Entom., Vol. 6, p. 115 (1913).
[3] Proc. Washington Acad. Sci., II, p. 578–579 (1900).
[4] Proc. Acad. Nat. Sci., Philadelphia, p. 335 (1895.)
[5] Journ. Econ. Entom., Vol. 6, p. 115 (1913).
[6] Journ. Econ. Entom., Vol. 6, p. 115 (1913).

Prof. H. A. Surface also writes that he has seen this insect abundant in Illinois.

Iowa.—Prof. H. F. Wickham writes: "About the distribution of *Stomoxys calcitrans*, I have no formal notes, but it is very common here, though perhaps less so than during my boyhood when little care was taken in the disposition of refuse."

Prof. O. A. Johannsen has also observed it personally at State Center, Iowa.

Kansas.—Bishopp [1] refers to this species as a pest of more or less importance every year in the grain belt of this state.

Kentucky.—Garman [2] speaks of *Stomoxys calcitrans* as extremely abundant at St. Vincent, Ky., during August, 1895, and observed the flies very commonly at Lexington, Ky., as late as October 20, 1890, sunning themselves in great numbers on the sides of buildings.

Maine.—Prof. O. A. Johannsen writes that the stable fly occurs at Orono, Me., where he has observed it personally.

Maryland.—Mr. S. N. Cory has kindly furnished the following notes on the occurrence of the stable fly in Maryland: "It is abundant in this state where we have bred it from horse- and hog-manure. In 1908 it was the species most abundantly bred out in the insectary from this material collected late in the fall.

Massachusetts.—Extensive observations, particularly in the eastern portion of the state have revealed an abundance and seasonal distribution similar to that which exists in most of our other northern states. The adults do not appear in noticeable numbers until the early part of June. They are then to be seen very generally in localities where there are many domestic animals, but not in sufficient numbers to annoy cattle or horses to any extent. At this time also they are much more local in occurrence, for they do not appear to wander far from barns, stables and pastured animals. In another month they have increased greatly in numbers and begin to appear quite generally in places quite removed from such animals, while horses and cattle are considerably annoyed by them. During August there is a still greater increase in their numbers, and it is during this month that animals are most severely bitten by them. At this time they can be seen in abundance almost anywhere, although as before they are most numerous in places where they can find large animals upon which to feed. During September they are scarcely less abundant, until the latter part of the month when they become much less active and are to be seen almost entirely on fences and walls,

---

[1] Journ. Econ. Entom., Vol. 6, p. 115 (1913).

[2] Ann. Rept. Kentucky Agric. Expt. Sta. (8th) for 1895, p. 1 (1896).

particularly if these are constructed of wood and painted. Even in the summer they are attracted to such warm surfaces in the full glare of the sun except during the middle of the hottest days; they then migrate to places illuminated by more slanting sunshine. In this way during a single day they will successively congregate upon such portions of a barn as present the desired warmth and sunshine. By October the activity of the flies is much diminished, and on cool mornings they remain in a dormant condition. However, as soon as the air becomes warmer, later in the day, they again become active, and at this time of the year almost replace the house fly which has decreased greatly in numbers. Even after a severe frost, they do not disappear entirely if the weather again becomes warm. In warmed stables they persist in greatly decreased numbers throughout the winter in a semi-active state, and stable-men recall having been bitten by them when sitting about heated stable stoves in the dead of winter.

There are a number of published references to the occurrence of the stable fly in Massachusetts, but they do not add materially to the above statement. It is interesting to note, however, that Harris [1] as early as 1842 speaks of cattle and horses being much tormented by the bites of these insects.

Michigan.—Prof. R. H. Pettit informs me in a letter that the stable fly is common throughout southern Michigan and that he has seen them extremely abundant in the northern part of the state a short distance from Mackinaw.

Minnesota.—Washburn [2] in his Diptera of Minnesota says that the stable fly is found in large numbers about stables in Minnesota.

Professor Washburn has also been so good as to inform me by letter that his observations would indicate that the species is quite common in the neighborhood of all the towns over the state.

Missouri.—Mr. Leonard Haseman writes from Columbia, Mo., that he has never seen the stable fly so abundant in any part of the United States where he has been, as it is in Missouri. He says that it is a great scourge of live stock and aside from the house fly and the horn fly, the most abundant fly breeding in horse-manure in the region about Columbia.

Mississippi.—Bishopp [3] states that the stable fly occurs commonly in Mississippi and sometimes becomes a considerable pest of live stock.

Montana.—Mr. William M. Mann tells me that the stable fly is a common insect in Montana.

---

[1] Insects Injurious to Vegetation, p. 412.

[2] Tenth Ann. Rept. Entom. Minnesota, p. 148 (1905—).

[3] Journ. Econ. Entom., Vol. 6, p. 115 (1913).

Nebraska.—Bishopp [1] refers to this species as a pest of more or less importance every year in the grain belt of this state.

New Hampshire.—Prof. W. C. O'Kane writes that he has specimens of the stable fly from Pelham, N. H., but that the species has not been reported by correspondents throughout the state during recent years.

The writer found the species very abundant at Wilton, N. H., on a visit there during the summer of 1911.

New Jersey.—Howard [2] quotes Dr. John B. Smith as having mentioned the abundance of this species in his house in New Brunswick, where he had noticed their increase in numbers during the late summer and fall, till by November 1st they had almost replaced the house fly at that place.

In his Insects of New Jersey it is referred to as "common throughout the state; a great pest of cattle" (Edit. 1890, p. 392; *id.* 1900, p. 679; *ibid.* 1910, p. 788).

New Mexico.—Prof. T. D. A. Cockerell writes that he found the stable fly abundant at Las Vegas, N. M., in 1900–01, and that he found it also at Pecos on the upper Pecos River and at Roswell.

New York.—As early as 1849 Fitch [3] speaks of the stable fly as most tormenting, especially to horses in New York state.

Prof. O. A. Johannsen writes that he has observed it at Ithaca, N. Y., and the writer has observed it commonly in the environs of New York city. Felt also records it [4] from New York without specific localities saying "that it may be rather abundant about houses in the fall."

Ohio.—Prof. J. S. Hine writes that he has observed this species in every part of Ohio in which he has been and Prof. H. A. Surface has seen it "abundant in the southeastern part of Ohio."

North Carolina.—Mr. Z. P. Metcalf writes that he has specimens of the stable fly from Raleigh, Beaufort and Southern Pines, and that he is sure of having observed it in other parts of the state as well.

Oregon.—Howard [5] mentions the appearance of extraordinary numbers of the stable fly near Salem, Ore., in 1888, and Prof. J. M. Aldrich writes me that he has this species in his collection from Corvallis, Ore.

Pennsylvania.—Prof. H. A. Surface writes that the stable fly is generally distributed throughout Pennsylvania, and says that he is

[1] Journ. Econ. Entom., Vol. 6, p. 115 (1913).
[2] The House Fly—Disease Carrier, p. 241 (1911).
[3] Trans. N. Y. State Agric. Soc., Vol. IX, p. 803.
[4] Bull. New York State Mus., No. 136, p. 7 (1910).
[5] The House Fly—Disease Carrier, p. 244 (1911).

not aware that there is any part of the state in which it does not occur.

Rhode Island.—Mr. C. W. Johnson has specimens from Kingston, R. I., and the species is evidently equally abundant in Rhode Island as in the adjoining states.

South Carolina.—Bishopp [1] states that the stable fly occurs commonly in South Carolina and sometimes becomes a considerable pest of live stock.

South Dakota.—According to Bishopp [1] statements by farmers in South Dakota indicate that the stable fly is sufficiently abundant there to become a live-stock pest.

Prof. J. M. Aldrich writes that he has specimens in his collection from Brookings and Custer, S. D., and that he has observed it as troublesome to horses in South Dakota.

Texas.—Very recently Bishopp [2] has referred to the great abundance of the stable fly in northern Texas during the summer of 1912 and to its prevalence in the same region every year. In the south central portion of the state, the present writer found the species always rather commonly, but not in excessive outbreaks during several years of residence there. It is undoubtedly very widely distributed in Texas and an extremely important pest of live stock in most if not all parts of the state.

Bishopp (l. c.) also says that this species was reported as extremely abundant in north central Texas as early as 1867, and that later outbreaks occurred in 1894 or 1895 and in 1905.

Pratt [3] records the species as very abundant in and about stables at Dallas, Tex., but as not breeding commonly in cow-manure according to his observations.

Virginia.—Howard [4] has found this species commonly in northern Virginia, and mentions its occurrence in out-of-door privies in this region.

West Virginia.—Howard [5] refers to the occurrence of adult stable flies in out-of-door privies at Charleston, W. Va.

Wisconsin.—Carlyle [6] records *Stomoxys calcitrans* as being very common and as constantly worrying stock, particularly cattle in the "Northwest." The writer has observed it in numbers in southeastern

---

[1] Journ. Econ. Entom., Vol. 6, p. 115 (1913).
[2] Journ. Econ. Entom., Vol. 6, p. 112–126 (1913).
[3] Canadian Entom., Vol. 44, p. 182.
[4] Proc. Washington Acad. Sci., II, p. 579 (1900).
[5] Proc. Washington Acad. Sci., II, p. 579 (1900)
[6] Ann. Rept. Wisconsin Agric. Expt. Sta. for 1889 (16th), p. 92 (1899).

Wisconsin, near Milwaukee, as well as in the more northern parts of the state.

Canada

Hutt [1] speaks of *Stomoxys calcitrans* as commonly found in houses in Ontario, and it is undoubtedly well distributed in at least the more southern parts of Canada.

Alaska

Mr. A. B. Parks who has collected insects extensively in Alaska writes that *Stomoxys calcitrans* occurs in Sitka and that he has seen it also at Skagway, 500 miles further north. At Sitka it was abundant around barns during July and August.

Bermuda

Mr. C. W. Johnson has kindly furnished me with a record of the occurrence of the stable fly in Bermuda, based on a specimen in his collection bearing the date of January 20.

Bahama Islands

Mr. C. W. Johnson has given me a record of the stable fly in the Bahamas, based on material in his collection and he has also made a published reference [2] to specimens taken at Nassau.

West Indian Islands

Porto Rico.—Coquillett [3] has recorded a single specimen from Vieques Island, contained in a small collection of Diptera made in Porto Rico.

Cuba.—Prof. J. M. Aldrich tells me that he has a specimen in his collection from Havana, Cuba.

Jamaica.—The writer has had the opportunity personally to observe the occurrence of this species in Jamaica. It seems nowhere to be so abundant as in temperate North America and is restricted mainly to the regions near sea level. I have never noticed it on mules or donkeys when traveling at altitudes of over two or three thousand feet.

There is also a published record by Newstead.[4]

Hayti.—Mr. William M. Mann, who has collected on this little-

[1] Rept. Entom. Soc. Ontario, No. 29, p. 100 (1898).

[2] Psyche, Vol. 15, p. 77 (1908).

[3] Proc. U. S. Nat. Mus., Vol. XXII, p. 256 (1900).

[4] Rept. 21st Exped. Liverpool, Sch. Trop. Med., Jamaica (1908–09), and Bull. Jamaica Dept. Agric., N. S., Vol. 1 (1910).

known island, informs me that he has commonly noticed stable flies biting his horse in various parts of Hayti.

St. Vincent.—Williston[1] has included *Stomoxys calcitrans* in his Diptera of St. Vincent.

Grenada.—The writer has seen the stable fly in Grenada, but at least during August and September it is not so numerous as to be a noticeable pest to domestic animals.

Mexico.—Van der Wulp[2] cites Tabasco, Orizaba and Mexico City as localities and Mr. W. M. Mann has recently observed it in the State of Hidalgo at an altitude of 9000 feet.

Costa Rica.—Van der Wulp[3] has recorded *Stomoxys calcitrans* from two localities, Caché and Rio Sucio.

Central America

Panama.—The writer has observed the stable fly in the Canal Zone during May, but in very small numbers. It does not appear to be an abundant insect in Panama.

South America

Colombia.—This species occurs at least in the coastal region of Colombia, near Buenaventura, where I have seen it, although in very small numbers.

Ecuador.—In the city of Guayaquil, Ecuador, and in its environs the stable fly was to be found occasionally during May and June, at the onset of the dry season, but not in noticeable numbers. Most of the specimens which I collected there are much smaller than those from more temperate regions.

Peru.—Prof. C. H. T. Townsend, an eminent authority on Muscoid flies, who has resided in Peru for a number of years, has been so good as to furnish information concerning the occurrence of the stable fly in that country. He writes: "I can say that *Stomoxys calcitrans* occurs throughout Peru below certain altitudes, which I would estimate at six or eight thousand feet and perhaps higher. It occurs throughout the coast region and I have universally noted it as very troublesome to my mules on trips in the montanya on the eastern side of the Andes, below six or seven thousand feet. . . . I have little doubt that it is distributed all over South America wherever suitable breeding conditions exist.

---

[1] Trans. Ent. Soc. London, 1896, p. 366.
[2] Biol. Cent. Amer. Dipt., vol. 2, p. 292 (1896).
[3] Biol. Cent. Amer. Dipt., Vol. 2, p. 292 (1896).

Since receiving this information I have been able to confirm these statements concerning its altitudinal distribution on the western slope of the Peruvian Andes. At Callao and Lima this insect was very abundant during June and July, 1913 (the beginning of the winter), and at San Bartolomé with an altitude of somewhat over 4,000 feet it was still common. At Matucana, however, which is about 7,300 feet above sea-level, I did not observe it.

Chile.—Cited by Reed[1] in his catalogue of Chilian Diptera.

Argentina.—The stable fly is an extremely common insect in many parts of Argentine and an extremely serious pest of cattle in many parts of that country. Dr. Juan Brethes of Buenos Ayres tells me that it attains at least the parallel of 35° south latitude and may perhaps extend further south, although he has no positive data in regard to this. They appear most abundantly in the fall (March and April) and at times in almost incredible numbers. Such a case has been described by Iches,[2] when, in 1908, the Province of Santa Fé was visited by a plague of these insects. In this case their unusual abundance was traced to large amounts of fermenting vegetable débris left after the threshing of wheat and flax.

Brazil.—Austen[3] has found specimens from the lower Amazon region in the collections of the British Museum, and many years ago Desvoidy[4] described *S. sugillatrix* (a synonym of *S. calcitrans*) from Brazil.

Great Britain

Hewitt, who has observed this insect extensively in England speaks[5] of it as being common, especially in the country from July to October, during which time it is frequently seen in houses. He also found it as early in the season as March and April upon the windows of a country house.

Newstead has also referred to its abundance in parts of England, particularly in Liverpool and Chester, where he found the adults resting on shop-fronts in the main city streets.

It is evidently very abundant and generally distributed in England, much as in our own country.

Europe

Stomoxys calcitrans was originally described by Linnæus from Swedish specimens and has since been recorded from practically all

[1] Cat. Ins. Dipt. Chile. Ann. Univ. Chile, Vol. 73, p. 644 (1888).
[2] Bull. Soc. Nat. Acclim. France, Vol. 56, p. 104–11 (1909).
[3] African Blood-sucking Flies, p. 143, London (1909).
[4] Myodaires, p. 386.
[5] Quart. Journ. Micr. Sci., Vol. 54, p. 356 (1909).

parts of Europe by various writers. Any attempt to enumerate these would occupy so much space that they have been omitted. To judge from published reports, the species appears to reach its greatest abundance in middle Europe, particularly in Germany and Belgium.

Russia.—Portchinsky[1] in an extended paper on the bionomics of *Stomoxys calcitrans* mentions its abundance in Russia. His remarks refer especially to the southern part, but seem to be applied very generally to the country as a whole.

Africa

Algeria.—Recorded by Bezzi[2] from "Algeria" without further notes.

The species is evidently not abundant, at least in certain parts of Algeria and Tunis, as it is not included in Becker's[3] list of Diptera taken by him in this region during the spring of 1906.

Abyssinia.—Drake-Brockman[4] records a number of interesting observations on the occurrence of *Stomoxys calcitrans* in eastern and southeastern Abyssinia. He found the species very common in the Hawash Valley and around Mount Fantali, "where they attack camels, horses, mules, cattle and human beings with equal vigour." It was also present over the great Arussi Plateau and in the region about the River Wabi between Seru Abbas and Mount Abuna. At Ginir, the great trading center for eastern Abyssinia, it was very abundant and troublesome, and also in Borana, a great cattle country northwest of Banissa.

Sudan.—Bezzi[5] lists this species from Asmara-Keren in Sudan, near Khartoum, and Austen[6] records it from Khartoum and Somaliland. Picard cites Bamako in French Sudan, and Roubaud[7] the Nigerian Sudan.

British East Africa.—Austen[8] records *Stomoxys calcitrans* from the East African Protectorate on the basis of specimens in the British

---

[1] Mem. Bur. Entom. Cent. Bd. Land Administration & Agric. St. Petersburg, Vol. 8 (1910).
[2] Bull. Soc. Ent. Ital. XXXIX, p. 92 (1907).
[3] Zeit. Hym. u. Dipt., Vol. 5, p. 372 (1907).
[4] Bull. Entom. Research, Vol. 1, p. 55 (1910).
[5] Bull. Soc. Ent. Ital. XXXIX, p. 105 (1907).
[6] African Blood-sucking Flies, p. 143, London (1909).
[7] Bull. Soc. Ent. France, p. 312 (1907).
[8] C. R. Acad. Sci. Paris, Vol. 152, p. 1347 (1910).
[9] African Blood-sucking Flies, p. 144, London (1909).

Museum. Duke[1] mentions its presence in Uganda, and also cites Austen.[2]

German East Africa.—Stuhlmann[3] in a paper on the Tsetse fly and the surra disease mentions the occurrence of *S. calcitrans* in certain parts of German East Africa, and Austen[4] states that it is apparently very common there. Grünberg[5] also records it as common.

Zanzibar Protectorate.—Austen[6] has recorded it from Zanzibar.

Lourenço Marquez.—Bezzi[7] lists this species from Delagoa and has more recently[8] referred to a number of specimens obtained in Lourenco Marquez by C. W. Howard, and Austen[9] states that there are also specimens in the British Museum, collected by McMillan who found it to be common everywhere.

Austen has cited (loc. cit.) specimens from this region in the British Museum.

Stomoxys calcitrans has been taken in Natal, as recorded by Austen (loc. cit.).

Austen records specimens from Pretoria (loc. cit.).

Cape Colony.—Bezzi[10] refers to "Capo" as an African locality for the occurrence of this species.

Rhodesia.—In connection with a report on trypanosomiasis in northwestern Rhodesia, Montgomery and Kinghorn[11] record the presence of *Stomoxys calcitrans* in this region.

Neave,[12] in a list of insects taken in the Luangwa Valley in northeastern Rhodesia, mentions taking two or more species of *Stomoxys*, and adds that the genus is relatively scarce and local in the Luangwa Valley, compared with the high ground on either side.

Portuguese West Africa.—Bezzi[13] records Egitto in Portuguese West Africa, 12° south latitude.

Angola.—According to Austen (loc. cit.) specimens have been taken by Wellman in abundance in parts of Angola.

---

[1] Rept. Sleeping Sickness Comm. Roy. Soc. London, No. 13, p. 89 (1913).
[2] Loc. cit.
[3] Ber. Land. u. Forstw. Deutsch-Ostafrika, Vol. 1, pp. 137–153 (1902).
[4] African Blood-sucking Flies, p. 144, London (1909).
[5] Zoöl. Anz., Vol. 30, p. 87 (1906).
[6] African Blood-sucking Flies, p. 144, London (1909).
[7] Bull. Soc. Ent. Ital. XXXIX, p. 92 (1907).
[8] Bull. Lab. Zoöl. Gen. & Agrar. R. Scuola sup. Agric. Portici VI, p. 98 (1911).
[9] African Blood-sucking Flies, p. 144, London (1909).
[10] Bull. Soc. Ent. Ital. XXIX, p. 92 (1907).
[11] A Report on Trypanosomiasis of Domestic Stock in Northwestern Rhodesia, Ann. Trop. Med. & Par. Vol. 2, pp. 97–132 (1908).
[12] Bull. Entom. Research, Vol. 1, p. 313 (1911).
[13] Bull. Soc. Ent. Ital. XXXIX, p. 92 (1907).

Congo Free State.—Austen cites its occurrence in Congo Free State where it is very common according to Todd[1].

Northern Nigeria.—One locality, Keffi, in the Province of Nassarawa is given by Austen.[2]

Gold Coast.—Various localities on the Gold Coast are cited for *Stomoxys calcitrans* by Austen (loc. cit.) on the basis of specimens in the British Museum.

Ivory Coast.—Picard[3] has seen specimens from the Ivory Coast.

Guinea.—In Guinea, Bezzi[4] records Togo as a locality, in latitude 8° south, longitude 0°, and Grünberg[5] also cites "Togo."

Gambia.—Bezzi[6] records the species as occurring in Gambia on the West Coast of Africa, latitude 14° north, and Austen[7] mentions a number of Gambian localities, based on specimens in the British Museum. Todd[8] also found it abundantly in this region.

Canary Islands

The species is recorded by Bezzi[9] from the Canary Islands without further remarks, and many years ago Macquart included it in his list of Diptera of these Islands.[10]

Quite recently Becker has referred to it,[11] but apparently only on the basis of Macquart's publication.

Madeira Islands

Becker lists this species in his enumeration of the Diptera of the Madeira Islands[12] and Prof. T. D. A. Cockerell writes that he is positive that he found it common at Furchal, Madeira, in 1879, though he does not find any reference to it in his diary of that year.

Azores.—Austen states that there are specimens in the British Museum from the Azores (loc. cit.)

---

[1] Ann. Trop. Med. & Paras., Vol. 1, p. 76 (1907).
[2] African Blood-sucking Flies, p. 143, London (1909).
[3] Bull. Soc. Ent. France, p. 312 (1907).
[4] Bull. Soc. Ent. Ital. XXXIX, p. 92 (1907).
[5] Zoöl. Anz., Vol. 30, p. 87 (1906).
[6] Bull. Soc. Ent. Ital. XXXIX, p. 92 (1907).
[7] African Blood-sucking Flies, p. 143, London (1909).
[8] Ann. Trop. Med. & Paras., Vol. 1, p. 76 (1907).
[9] Bull. Soc. Ent. Ital. XXXIX, p. 92 (1907).
[10] Hist. Nat. Iles. Canar. 114, 70 (1839).
[11] Mitth. Zoöl. Mus. Berlin, IV, p. 111 (1908).
[12] Mitth. Zoöl. Mus. Berlin, IV, p. 195 (1908).

Mauritius

According to Bezzi [1] the species occurs in this island as he gives the reference "Isola di Francia" without further remarks.

Asia

Seychelles Islands.—Recorded by Austen (loc. cit.) from specimens in the British Museum.

Persia.—Becker and Stein[2] record the occurrence of *Stomoxys calcitrans* in the Province of Baluchistan, Persia.

Palestine.—Recorded by Austen (loc. cit.) on the basis of specimens in the British Museum.

India.—F. W. Howlett, the Imperial Pathological Entomologist of the Agricultural Research Institute at Pusa in Bengal, India, has been so kind as to furnish the notes which follow, concerning the occurrence of the stable fly in India.

"*Stomoxys calcitrans* may, I think, be said to be common all over India. I have myself taken it at the following places: Pusa, Calcutta, Lebong (near Darjeeling and about 4,500 feet elevation), Allahabad, Simla (7,000 feet), near Mussoorie (at about 5,000 feet), Lahore, Bombay, Parel and Bassein (both near Bombay), Poona, Coonoor (near Ootacamund, a hill-station in the Nilgiri Hills), Coimbatore (at the foot of the same hills), and Madras.

"We have here the following genera of blood-sucking Muscidæ occurring fairly commonly: *Stomoxys*, *Lyperosia*, *Philæmatomyia* and *Hæmatobia*.

"Of these all save *Stomoxys* breed habitually in cowdung, but this rarely if ever breeds there but chooses fermenting vegetable stuff such as heaps of fodder or decaying grass.

Save in certain districts such as Assam (I have not been there but have heard that they bite people freely in some parts), I should say the risk of infection from their bite was less here than in England, for though the flies are often very common they seem to bite much less often than, for instance, at my home in Norfolk, England. Why this should be I have no idea, but it is certainly true for Pusa and several other districts where the flies are quite common. Possibly the humidity-conditions may have something to do with it. It is, of course, for most of the year comparatively or very dry over a large part of India."

Gravely [3] gives some interesting facts concerning some flies asso-

[1] Bull. Soc. Ent. Ital. XXXIX, p. 92 (1907).
[2] Ann. Mus. Zoöl. Acad. Imp. Sci. St. Petersburg, Vol. 17, p. 630 (1913).
[3] Rec. Indian Mus., Vol. 6, pp. 44–5 (1911).

ciated with cattle in the vicinity of Calcutta. He states that *S. calcitrans* together with *S. indica* Pic. (*limbata* Austen) occurred commonly on cattle during the day, but not at night, while *Philæmatomyia insignis* Austen was the most common blood-sucking Muscid on these animals.

Ceylon.—Brunetti [1] has mentioned the occurrence of *Stomoxys calcitrans* at Colombo, Ceylon, and it was recorded from Ceylon also by Schiner [2] at a much earlier date.

Siam.—Recorded by Austen (loc. cit.) on the basis of specimens in the British Museum.

China.—Howard [3] refers to the occurrence of *Stomoxys calcitrans* in China, but gives no further data as to its distribution and relative abundance in that country.

Hong Kong.—It is stated in the Report of the Colonial Veterinary Surgeon at Hong Kong for 1909, according to an abstract in the Experiment Station Record [4] that *Stomoxys calcitrans* and the horn fly are the two most common flies in cattle sheds, both causing cattle a great deal of annoyance.

Many years before Schiner [5] recorded the species from Hong Kong.

Singapore.—Brunetti [6] records *Stomoxys calcitrans* from Singapore.

Japan.—*Stomoxys calcitrans* is evidently a common insect in Japan, as Coquillett [7] found ten specimens in a not very extensive collection of Diptera from Japan. No specific localities are cited in this paper.

Australia

Dr. W. W. Froggatt, the government entomologist to New South Wales, has kindly written in regard to the occurrence of *Stomoxys calcitrans* in Australia that it "has a wide range over Australia, though I am not quite sure how far north it ranges."

As early as 1868 it was evidently present at Sydney, N. S. W., as Schiner records it from there in his Diptera of the Novara Reise (p. 311), and the British Museum contains specimens from New South Wales according to Austen (loc. cit.).

Queensland.—Austen records specimens from Queensland in the British Museum (loc. cit.).

---

[1] Rec. Indian Mus., Vol. 4, p. 72 (1910).
[2] Novara Reise, p. 311 (1868).
[3] The House Fly—Disease Carrier, p. 243 (1911).
[4] Vol. 22, p. 682 (1910).
[5] Novara Reise, p. 311 (1868).
[6] Rec. Indian Mus., Vol. 4, p. 72 (1910).
[7] Proc. U. S. Nat. Mus., Vol. XXI, p. 333 (1898).

Tasmania

Lea [1] has referred to *Stomoxys calcitrans* as "very common about stables and butchers' shops."

New Zealand

Hutton [2] includes this species in his list of New Zealand Diptera giving Christ church as locality and stating that it is an introduced form "commonly known as the horse fly."

Mr. G. M. Hudson has very kindly written me that "*Stomoxys calcitrans* is rare in New Zealand, though it occasionally enters houses and bites people, especially towards the latter part of summer."

Java

According to Schat,[3] *Stomoxys calcitrans* is common in Java where he regarded it as the chief carrier of surra among cattle. Brunetti [4] also speaks of its occurrence in Java.

As early as 1868, Schiner records it from Batavia, Java, in his Diptera of the Novara Reise (p. 311).

Sumatra.—*Stomoxys calcitrans* is included by Van der Wulp[5] in his report on Sumatran Diptera.

Philippine Islands

Dr. C. S. Banks, Chief of the Entomological Section of the Bureau of Science in Manila has very kindly furnished some information in regard to the occurrence of *Stomoxys calcitrans* in the Philippines. He writes that it "has been found all over the Philippine Islands up to an altitude of 800 meters (2,500 feet), and may, of course, be found above that, but I am giving data from my experience. It is not what one would call a pest here as it is in parts of the United States, seldom being seen in houses and very rarely biting human beings."

Banks [6] has also referred to it as being abundant at certain seasons in the Philippines, and speaks [7] of its common occurrence in dwellings at Taytay at which place it is also a great annoyance to horses.[8]

---

[1] Insect and Fungus Pests of the Orchard and Farm, Hobart, 1908, p. 108.

[2] Trans. New Zealand Inst., 1900, p. 69.

[3] Schat, P. T. Beiträge zu den Untersuchungen über die *Trypanosoma evansi* und zur Bekämpfung der Surra unter dem Hornvieh auf Java. Inaug. diss. Univ. Bern. 1911.

[4] Rec. Indian Mus., Vol. 4, p. 72 (1910).

[5] Midd. Sumatra Exped., p. 43 (1880).

[6] Philippine Journ. Sci. I, p. 1072 (1906).

[7] *Ibid.*, IV, Sec. B, p. 236 (1909).

[8] *Ibid.*, t. c., p. 239.

Hawaii

Van Dine and Norgaard [1] refer to the occurrence of the stable fly in Hawaii, and it was previously listed by Grimshaw in the Fauna Hawaiensis, vol. 3, p. 28. (1901). Austen (loc. cit.) also states that there are specimens from Hawaii in the British Museum.

SUMMARY

The stable fly (*Stomoxys calcitrans*) is one of the most widely distributed insects, rivalling the house fly in this respect. It occurs commonly in parts of every zoölogical region and practically throughout most of them. It is probably native to the palæarctic region from whence it has followed man in his migrations to all parts of the world. In the United States it was common in the vicinity of Philadelphia as early as 1776. It is not equally abundant everywhere that it occurs, but is much more common in temperate regions such as the United States and Argentina. In the tropics it occurs very generally, but almost always in lesser numbers than in cooler climates.

POWDERED ARSENATE OF LEAD AS AN INSECTICIDE

By W. E. HINDS, *Entomologist Agricultural Experiment Station, Auburn, Ala.*

Arsenate of lead was first found to have insecticidal value during the fight against the gypsy moth in Massachusetts about 1893. It was for many years used only in spray applications. The most common form in which it was put upon the market was that of a 50 per cent paste, that is, a paste or putty form which contained practically one half water. The disadvantages of the paste form were numerous. For instance, it necessitated the payment of freight upon one half of a shipment with no insecticidal value. Furthermore, paste stock was liable to dry out and become caked and hard and this drying naturally varied the quantity required to produce a spray solution of given strength and was also more difficult to work up into uniform suspension in water.

Accordingly, after extensive experimentation, several companies of insecticide manufacturers began to put out powdered arsenate of lead a number of years ago and this form of a valuable poison has

[1] Abstract of a Preliminary Report on Insects Affecting Live Stock in Hawaii, Proc. Hawaiian Live Stock Breeders' Assoc., Vol. 5, pp. 19–70 (1908).

become very popular. There is no question that arsenate of lead possesses many advantages over Paris green for most insecticidal uses, and the powdered form has come to be considered as more economical to buy, more convenient to store and to prepare for spraying, than is the paste form. In numerous comparative experiments, insect control from spray made up from powdered arsenate of lead has been just as good as with that made from the paste form.

Here in the South, powdered arsenate of lead has been used very extensively since the fall of 1911 for the control of the cotton worm and is rapidly coming into general use for application for the control of other leaf-eating insects, such as potato beetles. The same method of application as has been used for the cotton worm can be used for applying the powdered arsenate of lead as a dust for many other leaf-eating insects. This method of application by what is called the pole and bag outfit, as fully described in *Alabama Bulletin No. 164*, requires no expensive outfit and gives very rapid and convenient distribution to the poison.

In Alabama and Mississippi in the fall of 1911 at least 500,000 pounds of the powdered material were distributed for use in cotton-worm control. Many cotton planters started the fight against the worms with dust applications of Paris green. In many cases, however, the Paris green caused sores, both upon men and animals engaged in the application and workmen frequently refused to continue the work if obliged to use Paris green. Many of these same planters then turned to powdered arsenate of lead and continued their fight against the cotton worm with highly satisfactory results. In all the work that was done in Alabama with powdered arsenate of lead, we have yet to hear of a single sore from it upon either man or animal engaged in its application, or of a single case of internal poisoning resulting from this extensive use.

Publicity is given to the foregoing note at this time because of the fact that, during the past summer, certain parties have been scattering broadcast circular matter announcing in substance such grave danger of fatal poisoning from the use of powdered arsenate of lead that its manufacture and distribution ought to be prohibited by law. The parties from whom we received this circular matter are known to us as extensive manufacturers of another form of insecticide. Definite information regarding authentic cases of injurious effects from the use of powdered arsenate of lead were at once requested from the parties issuing the warning, but, during the several months that have elapsed meantime, not a word has been received from them.

This statement is issued in the hope that those who may have need to use any arsenical insecticide may not be misled. If there were real

danger in the use of powdered arsenate of lead, we would by all means seek to learn the truth and to inform the public accordingly. At the present time we know of no reason why anyone should hesitate to use powdered arsenate of lead in preference to Paris green or any other arsenical poison now commonly obtainable on the market.

The department of entomology of the Alabama Experiment Station is now making an investigation covering the use of various forms of arsenate of lead with a view to finding exactly what form is most effective, economical and generally satisfactory, for use with various insect pests, and we believe that this work will in the future be of real service, not only to the planters who may use these poisons but to the manufacturers as well.

THE WILT DISEASE OF GIPSY MOTH CATERPILLARS[1]

By R. W. Glaser and J. W. Chapman, *Bureau of Entomology*

Introduction

In August, 1912, we published a paper in *Science* entitled: "Studies on the Wilt Disease or Flacherie of the Gipsy Moth." More extensive observations and experiments conducted during the past year have led the authors to modify some of their original views concerning this disease. The work last year was carried on under rather unfavorable circumstances making elaborate experiments impossible. This difficulty was overcome through the courtesy of the Bureau of Entomology who supplied us with all of the necessary help and material.

Our observations in 1912 on the general behavior of the disease as influenced by external conditions, conclusions concerning the mode of infection and studies on the general pathology were on the whole correct, as far as they went, but a large series of experiments performed during the past summer have shown that we were too hasty in connecting etiologically a micrococcus with the disease.

Gyrococcus flaccidifex and the Blood Test

We described this micro- or diplococcus last year (1912) and believed it to be etiologically connected with the wilt disease. Since then it has proved to be simply a casual intestinal parasite in nature with which much of our laboratory material became infected. This micrococcus was isolated in pure culture and caterpillars inoculated or fed with it died of wilt after a comparatively short time. Our

[1]This will be followed by a bulletin of the Bureau of Entomology in which this disease will be treated more fully.

only explanation for this phenomenon at present is, that the caterpillars we thought healthy and used for the inoculation experiments were really infected with the virus and by giving them great quantities of this bacterium, we simply lowered their resistance to the disease and hastened death, which, in all probability, would have occurred sooner or later anyway. Another matter not to be overlooked is the apparent great resistance of many caterpillars towards the virus, provided other invaders or unfavorable conditions are excluded. The caterpillars used in the control experiments in 1912 did not die although doubtless some of them were infected, and the only feasible explanation for this seems to be that in one case, *i. e.*, in the inoculation experiments, the introduction of great quantities of a specific bacterium lowered the resistance of the animals towards the virus and death followed while in the other case, *i. e.*, in the controls no such bacterium was introduced.

Observations made on the blood of a great many individuals followed by a study of their tissues in section have clearly demonstrated that the polyhedral test for diagnosing the health of caterpillars is by no means absolutely reliable. The blood corpuscles of a caterpillar may not reveal polyhedral bodies, but this does not necessarily mean that the caterpillar is healthy, for sections through such an individual are very likely to show polyhedral bodies in the nuclei of the tissue cells. On the other hand polyhedral bodies may be present in the blood corpuscles and not in the tissues. These observations showed the futility of the blood test in diagnosing. It is a pity that it cannot be used for we have been compelled to substitute a rather more indefinite for a presumably more definite method.

Why Gyrococcus Was Eliminated

The reasons why we abandoned *Gyrococcus flaccidifex* are the following: If smears are made from caterpillars dead but a short time no bacteria can be found as a rule. Cultures made from such caterpillars on caterpillar and the ordinary nutrient media remained sterile, except in a very few cases when the bacterium in question again appeared. Of course, after a caterpillar has been dead for a certain length of time bacterial invaders entered the body, but cultures made from dying or freshly dead caterpillars rarely manifested growth. At the beginning when the disease first became epidemic in nature we made smears and cultures out in the field by taking with us all the necessary sterilization appliances and in so doing on quiet windless days we found the chances for contamination were very slight as compared with those in our laboratory where thousands of caterpillars had previously died.

As stated in our first paper dead caterpillars cannot be sectioned owing to the fact that they disintegrate completely after death. If serial sections are made of diseased caterpillars obtained in the field, polyhedral bodies will be found in abundance, but no bacteria in the tissues and in most cases the intestinal lumen will be perfectly free from microörganisms in general. This is a very striking fact when compared with the abundance of intestinal flora in the higher animals. Last year we stated that we had observed small wriggling things in the tissues which after being stained were revealed as Gyrococci. Small wriggling or rather dancing things are certainly found in the tissues of diseased caterpillars, and it is possible that we mistook these for Gyrococci. Pigment granules are also easily confused with bacteria as anyone knows who has studied the pigment granules in the basement membrane lining the hypodermis, and in the ganglia. The microörganism described as *Gyrococcus flaccidifex* when found proves to be an intestinal invader pure and simple. We will return to the small wriggling particles later.

Methods Used for Obtaining Healthy Material

After we realized that it was futile to depend upon the blood test for obtaining healthy material and that it was impossible to be certain of any material in the vicinity of the laboratory, field men were asked to report any places in the infested territory where the disease was not evident. As soon as such places were reported, we visited and carefully examined them ourselves. If any dead caterpillars were found and later on microscopical examination showed polyhedral bodies, living material from such a locality was not used. Caterpillars were only taken from places where the disease could not be found at the time of collection. The objection will at once be raised and rightly, that the disease may have been there in a latent form and that no one can tell by an external examination whether a caterpillar is healthy or not. We have studied the disease in the field as well as in the laboratory and have found it in all of the infested territory from Maine to Rhode Island. It will at once become evident what a difficult matter it is to obtain healthy material for experiments. Apparently the healthiest looking colonies harbor a number of diseased individuals, for sooner or later, if the place be carefully watched, the disease will appear. Then after all, the critic will say, you obtained your experimental material from a diseased locality. This is quite true, but the disease if present had not taken the form of an epidemic in such localities when the collections were made and the chances of obtaining some healthy individuals were very great. In places where the infestation is light and the caterpillars widely separated, the disease never reaches

an epidemic form throughout the entire summer and naturally many caterpillars escape since infection can probably only take place through the mouth by means of the food. Dead caterpillars disintegrate and their fluids soil the leaves, and other caterpillars on eating these become infected. Some experiments, to be mentioned later, seemed to show that this is the only way infection can occur. It at once becomes apparent why the disease plays such havoc in a heavily infested locality.

After being collected from a certain place some of the caterpillars were isolated in separate autoclaved boxes and placed in rooms which had never been used for this purpose. Others were kept together in what were known as stock boxes. Since it has, we believe, been accepted that unfavorable conditions assist the development of the disease, provided infection has occurred, the individuals in the different stock boxes were treated in a variety of ways. Some were starved, others were subjected to the heat of the sun, still others were fed with leaves soaked in water for forty-eight hours. After several days in case no disease appeared in either the isolated boxes or in those thus treated, it was thought safe to use them for the experiments. Several times during such health tests one or more caterpillars would contract the disease and then the entire collection was thrown away, the boxes were again autoclaved, and another lot brought in to be submitted to a similar physical examination. Such a method of obtaining healthy individuals proves to be much more satisfactory than the blood test as our controls show and if large enough numbers are used is perfectly safe. It was only owing to the large series of experiments which we performed as will be seen from our next publication that we were able to come to any conclusions at all concerning the virus of the wilt disease.

Exciting Agents Thought to Be Responsible for the Disease

A disease very similar to the wilt disease of the gipsy moth is known to attack the silkworm and the nun moth in Germany. In this country we have another similar disease in our two species of tent caterpillars, *Malacosoma disstria* and *M. americana*.

In Europe there is a tendency to group all of the caterpillar diseases which are characterized by the formation of polyhedral bodies under the name of "polyederkrankheit" or polyhedral diseases. This is an excellent way to distinguish them from those diseases not characterized by the formation of such bodies for, though we do not believe that the polyhedral bodies are the exciting cause of the disease, we are convinced, nevertheless, that they are absolutely specific for a certain type of malady.

European investigators have advanced various theories concerning the exciting cause of the polyhedral diseases. At one time bacteria were thought to be responsible, especially by Hofmann and Tubeuf. The polyhedral bodies were regarded as being formed by the tissue cells as a reaction against the bacterial toxins. In 1911 Escherich and Miyajima expressed the opinion that we must look upon the polyhedral bodies as the carriers of the virus. Bolle at one time believed a certain Microsporidian (*Microsporidium bombycis*) to be responsible for the disease. According to Prowazek's latest paper in 1912, on the "Gelbsucht" of the silkworm, Knoch delivered a lecture in Stuttgart on the 14th of March, 1912, in which he said that little refractive granules appear in the blood corpuscles. These multiply and infect the nuclei of tissue cells where their amoeboid membrane hardens and they change into polyhedral bodies. He further said that the minute granules which resemble the Chlamydozoa of Prowazek are the vegetative; the polyhedral bodies the resting stages of the causative organism.

Prowazek, in the paper above mentioned, infected some fifteen or sixteen caterpillars with emulsified diseased material which he passed with difficulty through the Berkefeld and through his Agar-Ultra filter. The filtrate contained no polyhedral bodies and no bacteria, as control cultures showed. The caterpillars died typically and so he concluded that in some cases healthy caterpillars could be infected with material free from polyhedra. These experiments are suggestive, but cannot be taken seriously because no controls were used and because the blood test was the only precaution taken in diagnosing the health of caterpillars.

THE EXCITING CAUSE OF THE WILT DISEASE A FILTERABLE VIRUS

Thirty filterable viruses are now known to be responsible for certain infectious diseases in man and the lower mammals, but to our knowledge only one has been described in insects, namely that of Sacbrood, a bee disease discovered by White in 1913.

In our infection experiments last year, we obtained negative results with the material passed through the Berkefeld filter. This was due to the fact that the material was so concentrated that a slimy film was deposited on the outside of the candle and withheld the virus. A concentrated emulsion of diseased material is so full of polyhedral bodies, cellular débris, hairs and pigment granules that it very soon plugs up the pores of the filters. This year caterpillars, which died typically of the disease, were crushed with just enough sterile water to facilitate the crushing. This material was then strained through cheese cloth and filtered by means of suction through filter paper. The filtrate was diluted in one case with fifty, in another with twenty-

five times its volume of sterile water. This was then passed through a Berkefeld "Grade N" filter and used for the infection experiments. The filtrate was sterile in so far as bacteria were concerned as control cultures on nutrient agar, gelatine and caterpillar soup showed. Microscopical examination showed no polyhedral bodies. Nothing could be observed even in a dark field except some very minute dancing granules also noticed by Prowazek in his experiments with silkworms (p. 272). These little granules may be identical with those observed in diseased tissue mentioned in the first part of this paper. This matter, however, is still so indefinite that speculation seems to be useless, but, since they were never found in the tissues of healthy caterpillars, their presence is worth recording.

A large number of caterpillars were fed with the Berkefeld filtrate smeared on red oak leaves. In order to establish uniformity in the experiments, all caterpillars of the same series were kept in one room where they could be subjected to the same degree of heat and humidity. Each caterpillar was kept in a sterilized pasteboard tray by itself, and fed with fresh red oak leaves after the infected leaves had been partially eaten. The oak leaves all came from a vicinity which was not infested with caterpillars. Thus the possibility of bringing the infection from the outside into the laboratory was excluded. Another matter considered was the age of caterpillars used in these experiments. If caterpillars are near the pupal stage, they cease feeding and are, therefore, difficult to infect, so it is important to get them young enough so that they will be sure to feed.

In one series of experiments fifty caterpillars were fed with the Berkefeld filtrate, in another forty, in a third twenty. The same number was fed with material before it was passed through such a filter and a large set of controls fed with Berkefeld filtrate which had been sterilized by autoclaving accompanied each series.

Out of the entire lot of caterpillars (110) fed with the unsterilized Berkefeld filtrate, twenty-eight died with typical wilt symptoms. Microscopical examination showed polyhedral bodies to be present in abundance and stained smears and cultures in nutrient broth showed that bacteria had taken no part. Quite a few of the caterpillars died of another cause which we will discuss more in detail at another time. Suffice it to say that the extreme heat during July of the past summer had much to do with the death of a great many of the caterpillars. Their death was due to disturbances in the normal physiological functions and not due to infectious disease. Caterpillars dying from this cause were not very flaccid, their skin was tough; they were not disintegrated, but more or less dried out. Polyhedral bodies were not present, but usually a great many crystals with radiating lines could

be found, a sign of some metabolic disturbance. Quite a few larvæ were killed by the imported tachinid parasite, *Compsilura concinnata*, and the rest transformed into moths. The only way we can account for these moths is on the supposition that they arose from immune caterpillars or from such as had escaped infection in some way. A greater number of caterpillars (48 out of 85) died in the experiments with unfiltered virus. This seems to show that the organism is filterable but with difficulty. The filter became clogged up after a short time and, therefore, only a certain amount of the virus could pass through it and, in order to overcome this difficulty in part, the old filters were replaced by new ones every few minutes. Among the entire number of controls, 162 caterpillars, only three died of wilt. This is equivalent to about 1.8 per cent, a very small percentage and one which can almost be overlooked as an experimental error in such a large set of controls when compared with the numbers that died in the experiments. In the controls as well as in the stock trays a great number of caterpillars died of the physiological cause already mentioned. Especially significant are those which died of this cause in the stock trays for these caterpillars were not at all infected, so that it is impossible to attribute the death-rate in the controls to some toxic effect of the sterilized virus. Laboratory conditions are poor at the best and our records show that very high temperatures were probably responsible for this "physiological death" as we have called it. In the laboratory, especially during high temperatures, the food plants put into trays dry out rapidly, no matter how often they are renewed. Dew and rain cannot wet them and very likely the lack of water, in other words thirst, was responsible for the mortality. We did not care to dampen the leaves artificially very much for fear that we might produce a condition still more unnatural and one that might favor the development of moulds in the trays.

The polyhedral bodies have as yet revealed nothing of a parasitic nature. They may, of course, be a resting stage of a filterable vegetative form, but we are rather inclined to regard them as reaction bodies. They are possibly products of nuclear digestion produced by the virus invading the nuclei and digesting the chromatin.

We should like briefly to consider one more matter. It is claimed in this country, notably by Mr. William Reiff, that the disease is air borne and that caterpillars can be infected in the woods by hanging out small cheese-cloth bags containing the remains of individuals that have died of the disease. With this point in view we arranged a set of boxes near some windows through which the wind blew steadily for over ten days. The boxes were closed except on two sides, namely the side facing the window and the side facing the interior of the room.

These were simply covered with cheese cloth through which the wind could blow. Two boxes were placed in each of three windows, and twenty caterpillars, were placed in each with an abundance of red oak leaves. To the windward of one box a little bag of material was hung prepared according to Reiff's receipt. The cheese cloth lining the windward side of another box was smeared with the juices of disintegrated caterpillars. The leaves in two boxes were smeared with the same juices and the two remaining boxes were kept as controls.

Twenty-one caterpillars died of the disease in the two boxes containing leaves smeared with the virus and one died in each of the control boxes. Two died in the box to the windward of which the bag was hung and three in the box lined with the smeared cheese cloth. In the experiment with the bag one died the day after the experiment was begun, so in all probability it had already been infected before being placed in the box, for one day is entirely too short an incubation period. In this same box four died of tachinid parasitism; all the rest transformed. In the controls three died of tachinid parasitism and the rest transformed. In the boxes in which the leaves were smeared four died of tachinid parasitism and the rest transformed.

While these experiments are not very extensive they, nevertheless, indicate that the wind is an unimportant factor in the rapid spread of the disease and that infection in nature occurs when caterpillars feed on leaves soiled by the juices of dead individuals. During the height of the season we found leaves everywhere with brown spots on them and, on making smears of such spots with some sterile water, polyhedral bodies were found in great abundance.

A very striking phenomenon observed in all of our experiments was the large number of moths obtained from caterpillars infected several times, both with the Berkefeld filtrate and with the unfiltered virus. This seems to us to be very suggestive of immunity and agrees with observations in the field where, in a given locality, the disease raged for several weeks and yet moths were later seen in abundance. They may have been fortunate enough to escape infection, but this seems improbable in a heavily infested area and was entirely impossible in the laboratory where they were infected several times.

Summary

Our experiments and observations may be summed up as follows:

1. The presence of polyhedral bodies in the blood corpuscles may be useful in diagnosing the health of nun moth caterpillars, but this test cannot be used for gipsy moth caterpillars with any degree of certainty.
2. The virus of the wilt disease is filterable with difficulty.
3. Such a filtrate is free from bacteria and polyhedral bodies.

4. Caterpillars dead from infection with the filtered virus are flaccid, completely disintegrated and full of polyhedral bodies.

5. Usually the complete absence of bacteria immediately after death is very striking as cultures and smears show.

6. Minute dancing granules were observed in the diseased tissue cells with very high powers.

7. These same granules were also noticed in the Berkefeld filtrate.

8. There is no evidence that the polyhedral bodies are stages of the filterable virus.

9. A large number of caterpillars used in the experiments died, due to disturbances in their normal physiological activities.

10. There is no evidence that the wind is an important factor in distributing the disease.

11. Infection naturally takes place through the mouth by means of the food.

12. Apparent immunity is a striking phenomenon.

Conclusion

In conclusion we wish to thank Professor William Morton Wheeler for the interest which he showed during the progress of our experiments. We also wish to thank Mr. A. F. Burgess, director of the Gipsy Moth Laboratory at Melrose Highlands, for the kindly coöperation which he has given us. Had he not provided efficient assistants to aid in feeding and looking after the trays, it would have been impossible to have accomplished much. We wish further to thank Miss Teresa Sheerin, one of our assistants, whose conscientious work and interest aided materially in our researches. Last, but not least, we would like to express our thanks to all the field men who assisted in this work.

BIBLIOGRAPHY

1886. Forbes, S. A. Studies on the contagious diseases of insects. Bull. of the Illinois State Laboratory of Natural History. Vol. II; pp. 257–321; figs. 2.

1905. Sawamura, S. On the large bacillus observed in flacherie. Bull. of the College of Agriculture. Tokyo Imperial University. Vol. VI; No. 4; pp. 375–386.

1906. Sawamura, S. Note on bacteria pathogenic to silk-worms. Bull. of the College of Agriculture. Tokyo Imperial University. Vol. VII; No. 1; p. 1.

1909. Wahl, Bruno. Über die polyederkrankheit der Nonne, I (*Lymantria monacha* L.) Centralblatt für das gesamte Forstwesen. Mitteilung der K. K. Pflanzenschutzstation in Wien, II. Trunnerstrasse 1, pp. 1–12; fig. 2.

1909. Reiff, W. Einige flacherie-experimente mit der "Gypsy moth" (*Liparis dispar*). Societas entomologica. Jahrg. XXIV; s. 178–181.

1910. Wahl, Bruno. Über die polyederkrankheit der Nonne II (*Lymantria monacha* L.). Centralblatt für das gesamte Forstwesen. Mitteilung der K. K. Pflanzenschutzstation in Wien, II. Trunnerstrasse I; pp. 1–42; Tafeln 3.

1910. Jones, H. N. Further studies on the nature of the wilt disease of the gypsy moth larvæ. Seventh annual report of the State Forester of Massachusetts. Public document No. 73; pp. 101–105.

1911. Wahl, Bruno. Über die polyederkrankheit der Nonne IV (*Lymantria monacha* L.). Centralblatt für das gesamte Forstwesen. Heft 6; pp. 1–22; Tafeln 5.

1911. Tubeuf, V. Zur Geschichte der Nonnenkrankheit. Naturwissenschaftliche Zeitschrift für Forst-und Landwirtschaft. Heft 8; pp. 357–377.

1911. Escherich, K. und Miyajima M. Studien über die Wipfelkrankheit der Nonne. Naturwissenschaftlichen Zeitschrift für Forst- und Landwirtschaft. Heft 9; pp. 381–402; fig. 6.

1911. Reiff, W. The wilt disease, or flacherie, of the gypsy moth. How to aid the spread of this disease. Published by the Bussey Institution of Harvard University. Pp. 1–60; plates 2; text figs. 5

1912. Wòlbach, S. B. The filterable viruses, a summary. Journal of Medical Research. Vol. XXVII; No. 1 (New Series, Vol. XXII; No. 1); pp. 1–25.

1912. Wahl, Bruno. Über die Polyederkrankheit der Nonne. V (*Lymantria monacha* L.) Centralblatt für das gesamte Forstwesen. Mitteilung der K. K. Pflanzenschutzstation in Wien II; Trunnerstrasse 1; pp. 1–23; Tafeln 6.

1912. Glaser and Chapman. Studies on the wilt disease or "flacherie" of the gypsy moth. Science, N. S., Vol. XXXVI; No. 920; pp. 219–224.

1912. Prowazek, S. V. Untersuchungen über die Gelbsucht der Seidenraupen. Centralblatt f. Bakteriologie, Parasitenkunde u. Infektions Krankheiten. I. Abteilung. Originale. Bd. 67; Heft. 4; pp. 268–284; Tabellen 2; text fig. 1.

1913. White, G. F. Sacbrood, a disease of bees. U. S. Department of Agriculture. Bureau of Entomology. Circular No. 169; pp. 1–5.

1913. Escherich, K. Neues über polyederkrankheiten. Referierendes und Kritisches. Naturwissenschaftlichen Zeitschrift für Forst- und Landwirtschaft. Heft 2; pp. 86–97; fig. 1.

ARTHROCNODAX CAROLINA N. SP.

By E. P. Felt, *Albany, N. Y.*

The species described below is allied to *A. apiphila* Felt from which it is easily separated by the lighter circumfili and the longer stems of the antennal segments in the male. It is easily separated from *A. occidentalis* Felt, a species recorded as preying upon red spider in California, by the shorter stems of the antennal segments in the male and by the rounded ventral plate. Mr. E. A. MacGregor, who reared this species in both 1912 and 1913 from red spider on cotton, is of the opinion that it is the most important natural agent in controlling this pest.

Male. Length .75 mm. Antennæ about as long as the body, sparsely haired, light brown; 14 segments, the fifth having the two parts of the stems with a length three-fourths and one and three-fourths times their diameters, respectively. The

circumfili are normally developed and not unusually thick or heavy. Mesonotum dark reddish brown. Scutellum and postscutellum yellowish. Abdomen yellowish brown. Halteres, coxæ and femora basally yellowish or pale straw, the distal portion of femora, tibiæ and tarsi slightly darker; claws slender, strongly curved, simple; pulvilli nearly as long as the claws. Genitalia; basal clasp segment long, stout, terminal clasp segment long, tapering; dorsal plate long, broad, deeply and triangularly emarginate, ventral plate short, broadly rounded.

Female. Length .75 mm. Antennæ extending to the fourth abdominal segment, sparsely haired, fuscous yellowish; 14 segments, the fifth with a stem one-fifth the length of the cylindric basal enlargement, which latter has a length a little over twice its diameter and sparse whorls of stout setæ basally and apically; terminal segment slightly produced, with a length over thrice its diameter, broadly rounded apically. Palpi; the third segment with a length about two and a half times its diameter, narrowly oval, the fourth segment one-fourth longer than the third, more slender. Color nearly as in the male, except that the thorax and abdomen are more orange. Ovipositor short, the terminal lobes narrowly oval and thickly setose. Color characters from microscopic preparations and, therefore, of only approximate value. Type Cecid. a2461.

Lepidoptera Breeding on Evening Primrose. Last year I found an interesting large-flowered evening primrose (*Oenothera hewetti* Ckll., Proc. Biol. Soc. Wash., XXVI, p. 203) in New Mexico, and secured a living plant for my garden at Boulder, Colorado. This plant, in the summer of 1913, grew to a very large size, and furnished the material from which the species was described. When gathering the seeds, I removed large numbers of whole pods, to save time, and presently (October) found that many small moths were issuing from them Most of these were *Mompha brevivittella* Clemens, but several were strongly marked with white, and belonged to *Mompha circumscriptella* Zeller. Although the moths were so abundant, they did not prevent me from getting enough seed to supply all my correspondents interested in *Oenothera*. It must be considered doubtful whether they are really injurious, since the normal crop of seed is enormously greater than would be required for the prosperity of the plant, supposing only a small fraction to grow. A third *Mompha*, *M. pecosella* Busck, has been found by me on the University Campus at Boulder, but it has not been bred. I am indebted to my kind friend Mr. Aug. Busck for the determination of all the moths. He tells me that at Dallas, Texas, Mr. W. D. Pierce bred *M. circumsciptella* from *Galpinsia hartwegi*. Doubtless the species of *Mompha* feed on various evening primroses, and presumably the common native host of those attacking *Oe. hewetti* in my garden is our very abundant *Oe. cockerelli* Bartlett in de Vries, 1913.

T. D. A. Cockerell.

Correction

Chinch Bug Egg Parasite. There seems to have been a somewhat ambiguous and unsatisfactory statement edited into the scientific note appearing on pages 425–26. The original stated in effect that Mr. A. B. Gahan (who will describe the species) concluded that the parasite represented a new genus and species of the Proctotrypidæ, a finding confirmed by Mr. Crawford of the United States National Museum.

E. P. Felt.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

DECEMBER, 1918

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. The receipt of all papers will be acknowledged.—EDS.

Nearly seven years have elapsed since the economic entomologists assembled at New Orleans. They have been years of progress and prosperity, at least so far as entomological developments in the southern part of the country are concerned. The Atlanta gathering will be largely attended by southern entomologists, and the investigator located in the north will have at this meeting a most excellent opportunity of talking with the men who are doing things in the warmer sections of this country, and through them obtain a better idea of their special problems. Entomologists at a distance are strongly urged to make an effort to be present and take part in a meeting which promises to be one of the most successful of recent years.

The stable fly, formerly held as a comparatively innocuous insect, stands convicted as a carrier of infantile paralysis and now the finger of suspicion[1] has been pointed at it in connection with the mysterious Pellagra, an infection which some have thought might be carried by species of Simulium. American investigations of this latter genus have failed to produce conclusive evidence of complicity on the part of Simulium, and it now remains to be seen if this latest arraignment will be followed by indictment. There is still much to be learned concerning the Diptera and it is to be hoped that the interest aroused in the groups containing pathogenic forms will be extended and result in studies of the numerous unknown flies and the bringing of our knowledge concerning the order up to a state comparable to that relating to the Coleoptera, Lepidoptera or Hymenoptera.

---

[1]1913, Jennings, A. H. and King, W. V. Amer. Jour. Med. Sci., 146:411. (Separate p. 1–30.)

Current Notes

Conducted by the Associate Editor

Alfred Russell Wallace died November 7, in the ninety-first year of his age.

A new insectary is being erected at Oklahoma College and Station.

A new nursery inspection law has been enacted by the legislature of Rhode Island.

Mr. J. W. Jeffrey, formerly State Horticultural Commissioner of California, is now engaged in organizing fruit growers' associations in that state.

Professor S. A. Beach, Professor of Horticulture at the Iowa Agricultural College, recently visited the orchard regions of Utah and the Pacific Coast.

Mr. U. C. Loftin has resigned as assistant in entomology at the Florida University and Station, to accept a position in the Bureau of Entomology.

Mr. W. W. Marshall of Nelsonville, Ohio, has accepted a position with the State Entomologist's office at College Station, Texas, with the rank of assistant entomologist. Mr. Marshall will assume the duties of his position on December 1.

Mr. Frank E. Lutz and Mr. Charles W. Leng have recently returned from an entomological collecting trip to Cuba, in the interests of the American Museum of Natural History of New York City.

Dr. O. M. Reuter, formerly Professor of Zoölogy in the University of Helsingfors, Russia, and an authority in Hemiptera-Heteroptera, died September 2, aged sixty-three.

Mr. Gordon W. Ells, B. S., a graduate in the class of 1913, Massachusetts Agricultural College, has been appointed assistant entomologist at the Agricultural Experiment Station, Auburn, Ala.

At Smith College, Northampton, Mass., a new biological hall is being erected in which the department of zoölogy and botany will be situated. The trustees have appropriated $140,000 for the new building.

Dr. Robert Matheson has resigned as Provincial Entomologist of the Province of Nova Scotia, to accept the position of investigator in entomology in the Cornell Agricultural Experiment Station, Ithaca, N. Y.

Mr. R. H. Van Zwanlenburg, B. S., a graduate of the Massachusetts Agricultural College, class of 1913, has been appointed entomologist of the Federal Agricultural Experiment Station at Mayaguez, Porto Rico, in place of the late Dr. C. W. Hooker.

An apiary inspection law was passed by the state legislature of Arizona at its last session. The law became effective on July 5, and the governor has appointed Mr. J. P. Ivy as state inspector.

Mr. H. S. Smith, superintendent of the California State Insectary, was sent in August for a two or three months' trip to the Orient, in search of the natural enemies of the various scale insects attacking citrus fruits in California.

The Extension Department of the Agricultural and Mechanical College of Texas is offering correspondence courses in "Elementary Entomology" and "Economic Entomology." The work is in coöperation with the Entomological Department of the college and is under the supervision of Professor Wilmon Newell.

Mr. William Moore of Cornell University, who for the past three years has been in South Africa, has accepted a position in the Entomological Division, Agricultural College, University of Minnesota, and has charge of the Section of Truck Crop and Greenhouse Insects and of the Insectary of the Division.

Mr. Leroy Childs, field assistant of the Bureau of Plant Industry, United States Department of Agriculture, and a graduate of Leland Stanford University, class of 1913, has recently been appointed assistant secretary of the California State Horticultural Commission.

Mr. Sherman W. Bilsing, formerly Fellow in the Department of Zoölogy and Entomology at the Ohio State University, has been appointed to the position of instructor in entomology at the A. & M. College of Texas. Mr. Bilsing assumed the duties of his new position on August 15.

Dr. P. R. Uhler, author of many papers on Hemiptera, died October 21, at the age of seventy-eight. Dr. Uhler described many American species of insects, especially Hemiptera; for twenty-two years he has been provost of the Peabody Institute at Baltimore.

H. M. Russell, after an absence of a few months on furlough, has returned to continue his work with the Bureau of Entomology. He is now in the Salt River Valley of Arizona, engaged in sugar beet leaf hopper investigations. Address, Office of the State Entomologist, Phoenix, Ariz.

Messrs. E. W. Laake and L. J. Bower, recent graduates of the Texas Agricultural College, have accepted positions in the Bureau of Entomology. Mr. Bower is at present located at the Bureau laboratory at Wellington, Kan., and Mr. Laake is engaged in the boll-weevil investigations at the Bureau laboratory in Dallas, Texas.

Benjamin W. Douglass, formerly state entomologist of Indiana, is entomological expert, and Frank Wallace, formerly assistant state entomologist, is secretary and treasurer, of the State Forestry Company, Indianapolis, Ind., a company formed to do business in landscape gardening, tree surgery, and to give advice in all horticultural matters.

Dr. J. F. Illingworth, professor of entomology in the College of Hawaii, spent three months in the Fiji Islands during the past summer. He went in the interest of the Colonial Sugar Refining Company, taking down a large colony of the Tachinid flies, which have proved such effective parasites of the sugar-cane borer in the Hawaiian Islands. The flies did splendidly in the cages in Fiji and a number of good sized colonies were liberated in the infested districts.

The State Horticultural Commission of California has recently placed a quarantine on the states of Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Pennsylvania, Maryland, Virginia, West Virginia, North Carolina, Tennessee, Kentucky, Ohio, Michigan, Illinios, Kansas, Arkansas, Nevada, and Florida, on account of the diseases known as "Peach Yellows" and "Contagious Peach Rosette."

Mr. Alfred B. Champlain, assistant in the Division of Economic Zoölogy, Department of Agriculture, Harrisburg, Pa., resigned September 1, to accept a similar position in the Bureau of Entomology of the United States Department of Agriculture, Washington, D. C. He will work on forest insect investigations under Dr. A. D. Hopkins, and is soon to travel through Colorado, Arizona and New Mexico, studying forest insect conditions there.

Mailed December 15, 1913

INDEX

Acer negundo, 422, 423, 424.
platanoides, 422, 423, 424.
rubrum, 421, 422, 423, 424.
saccharinum, 421.
saccharum, 421, 423, 424.
spicatum, 422.
Achras sapotes, 156.
Acrobasis caryæ, 197, 199.
Acrobatic fly, 330.
Adalia bipunctata, 404, 405, 408.
Agallia uhleri, 426.
Agropyron biflorum, 143.
Alabama argillacea, in Peru, 244–46.
clover, 362.
Alfalfa, 189, 192, 194.
butterfly, 192.
gall midge, 194.
Allorhina mutabilis, 193.
nitida, 193.
American Association Economic Entomologists, VII–XVI.
elm, 285.
Anasa tristis, 190.
Anastrepha fratercula, 345.
peruviana, 345.
Anisocalvia duodecimmaculata, 406.
quatuordecimguttata, 406.
Anthocoptes transitionalis, 420.
Anthonomus vestitus, 10, 11, 303, 304.
Ants, 195.
Aphelinus fuscipennis, 144, 273, 320.
mytilaspidis, 144.
quaylei, 320.
Aphis, 10.
avenæ, 406.
brassicae, 190.
gossypii, 190.
pomi, 406.
sorbi, 406, 457.
viburni, 406.
Aphycus flavus, 301.
sp., 294, 295, 300.
Apiculture, means of promoting, 418–20.
Apple, 62, 64, 65, 66, 76, 157, 158, 160, 166, 167, 168, 169, 170, 174, 175, 176, 177, 178, 193, 240, 313, 316, 390, 396, 412.
Apple and cherry ermine moths, 63.
leaf-hopper, 240–43.
maggots, 79.
scab, 165, 177.
Apricot, 263.
Archips argyrospila, pupal instar of, 396–98.
Archytas piliventris, 235, 257.
Argas persicus, 96.
Argentine ant, 294.
Arrhenophagus chionaspidis, 322.
Arsenate of lead, 61, 80, 157, 158, 159, 166, 365, 478.
powdered, 477–79.
Arsenic, white, 440.
Arsenical residues on fruit, 159.
Arsenite of zinc, 365.
Arthrocnodax carolina, 488–89.
occidentalis, 87.
Artichoke, 178.
Ash, 76, 78, 178.
Asphondylia capparis, 279.
miki, 194.
Aspidiotiphagus citrinus, 319.
Aspidiotus ostreæformis, 144.
rapax, 144.
Aster, 180, 238, 410.
Australian lady-bird beetle, 256.
Autographa brassicæ, 144, 145.

Bacillus amylovorus, 178.
Bananas, 68, 70, 71, 73, 328.
Barbiero fever, 105.
Barley, 117.
Bean, 189, 190, 325.
lady bug, 193.
Bed-bug, 104, 109, 189, 217, 382.
Bees, 187, 418.
Beech, 410.
Bell pepper, 362.
Bermuda grass, 362.
Birch, 410.
Birds, 255, 360.
Bird lice, 82.
Bishopp, F. C., 112–26.
and King, W. V., 200–11.
Bitter-rot, 166, 170, 173.
Blackberry, 178, 410.
Blackbirds, 236, 254, 257.
Black cherry aphis, 406, 457.
leaf 40, 65, 414.
locust, 178.
fly, 112.
maple, 422, 423, 424.
scale, 293, 294, 300, 301.
wasp, 456.
Bleeding trees, 285.
Blight canker, 178.
Blood sucking cone nose, 189.
Blow fly, 111.
Blue grass, 362.
Boll weevil, 57.
Bordeaux, 157, 158, 166, 173, 454.
Bot flies, 111.

Box elder, 178.
Bran, 236.
Britton, W. E., 89–93; 197–99.
Brown lace wing, 87.
Brown-tail moth, 74, 79, 134, 136, 159, 331, 332; attempts to trap, 74.
Bruchophagus funebris, 194.
Brues, C. T., 101–109, 459–77.
Bud moth, 198, 199.
weevils, 12.
Buffalo gnats, 217.
Burgess, A. F., 258–59; 286, 427.
and Rogers, D. M., 75–79.
Butternut, 177.
Buttrick, P. L., 352–59.

Cabbage, 157.
louse, 190.
Cacao canker, 442.
pods, 441, 442.
California red scale, 191, 192.
Calosoma alternans, 235.
calidum, 364.
Camphor tree, 413, 414.
Campylomma verbasci, 64.
Cantharoctonus stramineus, 308.
Capparis ægyptiaca, 279.
spinosa, 279.
Campsomeris dorsata, 254, 255.
Carabid beetle, 235.
Cardin, Patricio, 330.
Carolina poplar, 412.
Carpocapsa pomonella, 192.
Carpophilus dimidiatus, 193.
Cassaba melons, 190.
Cassava starch, 452.
Castnia licus, 448, 453.
Castolus plagiaticollis, 247, 453.
Castor bean, 325.
Catalpa, 178.
Catolaccus townsendi, 308, 309.
Cecidomyia peritomatis, 280.
Cerambycobius peruvianus, 308.
townsendi, 308.
Ceratitis capitata, 68, 70, 347.
Ceratophyllus gallinæ, 84.
Ceratopogon hippocastani, 285.
Cerchysius sp., 301.
Ceresa bubalus, 412.
taurina, 411, 412.
Changa, 149.
Charcoal, 456.
Chelonella townsendi, 308.
Cherry, 62, 64, 66, 79, 80, 81, 177, 178, 396.
fruit-flies, 79–80.
sawfly leaf-miner, 62.
Chestnut, 76, 77, 78, 177.
bark disease, 281, 404, 405.
Chilocorus bivulnerus, 273.
similis, 224, 322.
China tree, 191.
Chinch bug parasite, 425, 489.
Chinese banana, 400.
Cholera, 32, 35.
Chrysomphalus aurantii, 191, 299.
Cigarette beetle, 226.
Cirphis latiuscula, 257.
Citellus beecheyi, 205.
columbianus, 209.
Citrus, 85, 86, 88, 150, 161, 189, 191, 192, 293, 345, 347.
buxifolius, 401.
medica limonum, 400.
red spider, 87.
thrips, 186, 189.
Clover, 238, 278, 283.
leaf weevil, 284.
seed chalcis, 194.
Coccinella novemnotata, 404, 406, 408.
transversoguttata, 404, 406.
Coccophagus lecanii, 294, 295, 298, 299, 300, 303.
lunulatus, 294, 295, 299, 300.
Coccus hesperidum, 11; parasites of, 293–303.
sacchari, 252.
Cockerell, T. D. A., 142–43; 279–80; 424, 425, 426, 489.
Cockle bur, 362.
Cockroach trap, 327–29.
Coconuts, 442.
Codling moth, 36, 166, 170, 171, 173, 175, 176, 192, 270, 389; brood study of, 389–95; one spray, 173–75.
Coffee, 150.
ant, 150.
Colorado potato beetle, 193.
Compsilura concinnata, 485.
Confused flour beetle, 40.
Conorhinus sanguisugus, 189.
Conotrachelus juglandis, 197.
Conventzia hageni, 85.
Cooley, R. A., 93–95.
Cordyceps barberi, 254.
Corn, 30, 231, 278, 362, 365, 425, 426, 445.
ear worm, 192.
silk, 342.
Corthylus punctatissimus, 427.
Corythuca ciliata, 407–8.
Cosmocomoidea morrilli, 249.
Cotton, 11, 36, 245, 304, 305, 307, 309, 310, 312, 318, 319, 325, 326, 362, 365.
boll weevil, 311.
insects, 11.
leaf-caterpillar, 244.
moth flight, 426–7.
square-weevil, 10, 303.
worm, 478.
Cottonwood, 178.
Cow pea, 362, 365.
weevil, 147.
manure, 463.
Crab apple, 412.
grass, 362.
Cricket, 150.

Crotophaga ani, 236, 255.
Crown gall, 267.
Crow, 365.
Cryptolæmus montrousieri, 12, 256.
Cryptothrips floridensis, 413–14.
Culex pipiens, 93.
sollicitans, 91, 352.
Curculio, 166, 169.
Currant, 178.
Cut-worm moths, 267.
Cyanopepla submacula, 249.
Cycloneda sanguinea, 149, 257, 404.
Cypress, 278.

Dacus zonatus, 348.
Daictimorpha peruviana, 308.
Diaprepes abbreviatus, 455.
Dahlia, 410.
Daisy, 238.
Date palm, 192, 193, 415.
scales, 186, 192.
Daucus carota, 180.
Davidson, W. M., 396–98.
Davis, J. J., 276–78.
Dean, G. A., 40–53.
Deer fly, 112.
Delphax saccharivora, 251, 252, 256.
Demerara, Trinidad and Barbadoes trip, 443–57.
Dengue, 31, 104.
Dermacentor venustus, 93, 200, 210.
vulpinus, 55.
Dew, J. A., 361–66.
Diabrotica graminea, 257.
Diaprepes abbreviatus, 256.
Diarrhea, 34, 107.
Diaspis pentagona, 321, 322.
Diatræa canella, 445.
grandiosella, 247, 248.
lineolata, 445.
saccharalis, 12, 247, 251, 252, 253, 254, 445.
Dicraneura cockerelli, 191.
Distillate oil, 66.
Doane, R. W., 366–85, 437–42.
Dogwood, 178, 410.
Dolichoderus bituberculatus, 143.
Doryphora decimlineata, 193.
Douglas fir-seed chalcid, 283.
Drosicha contrahens, 143.
corpulenta, 143.
lichenoides, 142, 143.
maskelli, 143.
stebbingi, 143.
Dyar, H. G., 336.
Dysentery, 32, 34.

Eastern grape leaf skeletonizer, 192.
peach tree borer, 193, 263, 264.
rose chafer, 193.
Econonomic Entomologists, 26th annual meeting, 427.
Proceedings, 1–126; 157–257; 293–329.
Economic Entomology, Second International Congress, 88.
Ectatomma tuberculatum, 309, 312.
Egyptian cotton, 190.
Eight-lined Gypona, 409.
Elder, 178.
Elis sexcincta, 254, 255.
Elm, 157, 177, 178.
Emposca mali, 240.
English sparrow, 365.
walnut, 197.
Eniscopilus purgatus, 365.
Enteritis, 33, 34.
Entomological bulletin, arrangement of material, 180–84.
conferences in Porto Rico, 148–50.
nomenclature, 340.
pioneering, 185–95.
Society of Ontario, 150.
Ephestia kuehniella, 144.
Epilachna corrupta, 193.
Ericoccus borealis, 424.
Erigeron canadensis, 178, 238.
Eriophyes confusus, 421.
elongatus, 421.
maculatus, 421.
major, 421.
modestus, 421.
negundi, 422.
ornatus, 422.
parallelus, 422.
regulus, 422.
Ermine moth, 66.
Escherich, K., 430.
Essig, E. O., 270–73; 289.
Eucelatoria australis, 246.
European grain aphis, 406.
Eurytoma piuræ, 308.
Eusemion longipenne, 294, 301, 302.
Eutettix tenella, 191.
Euthrips citri, 186.
pyri, 62.
tritici, 189.
Euvanessa antiopa, 157.
Ewing, H. E., 404–7.

Fall army worm, 230, 361–66.
webworm, 157.
False tarnished plant-bug, 64.
Federal Horticultural Board, 340.
plant quarantine act, 133–42.
Felt, E. P., 160–61; 173–75; 278–79; 283, 284, 331, 427, 488–89.
Ficus nota, 143.
Field larks, 365.
Fig, 191, 193.
eater, 193.
Filaria, 219.
Filariasis, 27, 371.
Fire-ant, 256.
Fish oil, 126.
soap, 244.
Flax, 470.
Flea, 81, 104, 109, 217, 378.

Flour, 43, 44.
Flower or grain thrips, 189.
Folsom, J. W., 429.
Forbes, R. H., 415–16.
Forest entomology, society, 282.
Foul brood, 187.
Fowl bug, 81.
Fowls, domestic, external insect parasites of, 81–84.
Froghopper, 444, 451, 452, 453, 454, 455.
Frontina archippivora, 235, 257.
Fruit tree leaf roller, 396.

Gadflies, 105.
Gasoline torch treatment of date palm scales, 415–16.
Gates, B. E., 418–20.
Geotropism, negative, 407–9.
Giant moth borer, 448, 449, 451.
Gipsy moth, 65, 75, 76, 78, 134, 136, 141, 298, 477; conference, 286; experiments in controlling, 75–79; remarks, 258–59; work, reorganization of, 331; wilt disease, 479–88.
Glaser, R. W., and Chapman, J. W., 479–88.
Glossina morsitans, 367.
palpalis, 367.
Glucose, 157.
Goldenrod, 178, 180.
Gonia crassicornis, 235, 257.
Gouty pine midge, 331.
Grain, 55, 463.
Grape, 64, 178.
leaf hopper, 191, 240.
phylloxera, 190.
Grasshoppers, 248.
mice, 224.
Grass looper, 236.
Grass worms, 231, 232, 234, 236.
Gray birch, 76, 78.
Green apple aphis, 406.
June beetle, 193.
muscardine disease, 453.
peppers, 402.
Ground squirrel, 209.
Gru-gru worm, 454.
Gryllodes muticus, 150.
Gryllotalpa hexadactyla, 252, 253.
Guavas, 156, 345, 346.
Gypona cana, 412.
flavilineata, 410.
octolineata, 409–13.
Gyrococcus flaccidifiez, 480.

Hadley, C. H., Jr., 74.
Hæmatobia, 105.
serrata, 124.
Harrisina americana, 192.
coracina, 192.
metallica, 192.
Harvester ant, 194.
Haseman, Leonard, 237–40; 240–43; 313–16.
Harte, C. R., 426–7.
Hawthorn, 64, 177.
Headlee, T. J., 130–33; 389–95.
Heart-water, 110.
Heat as means of controlling mill insects, 40–53.
Heidemann, Otto, 249–51.
Heliothis armigera, 192.
Hemerobius californicus, 87.
Hemichionaspis aspidistræ, 322.
minor, 9, 11, 318, 319, 320, 321, 322.
Hemisarcoptes malus, 320.
Hemlock, 78.
Hen flea, 84.
louse, 82.
Herms, W. B., 430.
Herrick, G. W., 79–80; 81–84; 152.
Hessian fly, 36.
Heterocordylus malinus, 64.
Heterogeomys hispidus, 248.
Hewitt, C. G., 274–76.
Hickory, 76.
Hinds, W. E., 477–79.
Hippodamia convergens, 404, 405, 406.
parenthesis, 404.
spuria, 404, 406.
Hodge, C. F., 110–12.
Hodge fly trap, 328, 329.
Hodgkiss, H. E., 243–44; 420–24.
Holloway, T. E., 341–44.
Holoquiscalus brachipterus, 236, 255.
Home-made kerosene emulsion, 242.
Homœsoma electellum, 426.
Honey locust, 178.
Hooker, C. W., 148–50; (Obituary), 334; (Writings), 336.
Horsechestnut, 285.
Horismenus urichi, 249.
Horn-fly, 105, 111, 124.
Horse flies, 217.
manure, 117, 124.
weed, 178.
Horticultural inspectors, proceedings, 127–42; 258–69.
House fly, 28, 34, 35, 105, 109, 111, 124, 193, 195, 367, 372, 460.
How contact insecticides kill, 160.
Howard, L. O., 88, 336.
Hungerford, H. B., 165–73.
Hunter, S. J., 96–99; 196–97.
Hunter, W. D., 27–39.
Hydrocyanic acid gas, 40, 41, 44, 45, 53, 54.
Hypera punctata, 284.
Hyphantria cunea, 158.

Ihle, Paul, 430.
Imagination and facts, 147–48.
Imperial Bureau of Entomology, 274–76.
Indian cattle, 32.
Insect collections, Kansas University, 283.

Insect and disease, literature, 366–85.
bibliography, 368–85.
Inspection, What besides, 265–69.
Iridomyrmex humilis, 294.
Irish potatoes, 188, 193, 362.
Iron sulphide, 159.
Italian pear scale, 164.
Itonida anthici, 278–79.
inopis, 331.
Ixodes æqualis, 205.

Johnson grass, 362.
Johnston, F. A., 144–47.
Jonathan tree, 411.
Jones, T. H., 230–36.
Juglans regia, 197.
Juniper, 76.

Kaffir corn, 362.
Kala-azar fever, 104.
Kerosene, 90, 91, 347, 348, 349, 350, 440.
Kerosene emulsion, 65, 163, 164.
Knab, F., 336.

Lachnosterna arcuata, 276.
grubs, 455.
tristis, life cycle of, 276–78.
Lady-bird beetle, 12, 149, 257.
Laphygma frugiperda, 252, 257, 362; in Porto Rico, 230–36.
Larger moth borer, 455.
Lasioderma sericorne, 226.
Lead arsenate, 166, 176, 198; paste, 157.
Leaf cutter bees, 194, 195, 425.
miner, 150.
Leather beetle, 55.
Lecanium corni, 295, 298, 299.
hesperidum, 186, 191.
Leishmania, 219.
Lemon, 399, 400.
Leprosy, 32, 371.
Leptodictya tabida, 248, 249.
Leptoglossus zonatus, 186, 190.
Lesser apple worm, 176.
Leucoptera coffeella, 150.
Lice, 104, 109, 217, 384.
Ligyrus rugiceps, 255.
Lilac, 177.
Lime-sulphur, 157, 158, 164, 173, 244, 266, 270, 271, 272.
Lina scripta, 158.
Limotettix exitiosus, 426.
Liquid chocolate, 328.
Lissorhoptrus simplex, 55–61.
London purple, 194, 195.
Lygæus facetus, 426.
Lygidea mendax, 64.
Lygus invitus, 64.
pratensis, 64, 237.

Macrodactylus subspinosus, 193.
uniformis, 193.
Macrosiphum pisi 457.
Malaria, 31, 32, 33, 34, 36, 93, 100, 104, 217, 370.
Malacosoma americana, 483.
disstria, 483.
Malojillo, 231, 232, 233.
Mamestra picta, 158.
Mangoes, 156.
Maple, 76, 77, 78, 160, 177, 178, 410, 420.
mites, new species, 420–24.
Mare's tail, 238.
Margaropus australis, 223.
Marlatt, C. L., 133–42.
Marlatt scale, 192.
Marmota flaviventer, 209.
May-beetles, 12, 149, 252, 253, 254.
McColloch, J. W., 425–6.
Mealy-bug, 143, 251.
Medical entomology, 27–39.
Mediterranean flour moth, 41.
fruit fly, 134, 135, 140, 149; danger of introducing into United States, 68–73; life history and list of fruits attacked, 399–403; trapping, 347–51.
Megachile addenda, 425.
cleomis, 425.
generosa, 425.
lippiæ, 425.
Megastigmus spermotrophus, 283.
Megilla fuscilabris, 408, 409.
innotata, 149, 257.
Melanconium sacchari, 256.
Melon, 325.
Melon fly, 70.
louse, 190.
Metamasius hemipterus, 251, 252, 253, 256, 450, 454, 455.
sericeus, 248.
Metarrhizium anisopliæ, 247, 452.
Mexican fruit fly, 156, 269.
orange fruit fly, 134.
sugar cane insects, 247–49.
Microbracon juglandis, 144.
vestiticida, 308, 309.
Microsporidium bombycis, 484.
Microterys flavus, 294, 295, 300, 301, 303.
Military grasshopper, 189.
Millett, 362.
Minute Hymenopterous parasites, methods of handling, 341–44.
Miscible oils, 160, 242.
Mocking bird, 365.
Molasses, 157, 236, 401.
Mole-cricket, 12, 252, 255.
Mompha brevivittella, 489.
circumscripta, 489.
pecosella, 489.
Monanthia tabida, 249.
Morelos orange worm, 345.
Morgan, A. C. and Runner, G. A., 226–30.
Morrill, A. W., 185–95; 261–65.

Mosquito, 28, 29, 35, 104, 109, 195, 217, 352, 368.
control in Connecticut, 89–93.
Mountain maple, 422.
Mullen, 239.
Murtfeldt, Mary Esther (Obituary), 288.
Musca domestica, 124.
Mycetobia pallipes, 285.
Myiasis, 373.
Myrmelachista ambigua ramulorum, 150.
Myzus cerasi, 406, 457.
Myzine sexcincta, 255.

Nemorea leucaniæ, 365.
Neosigniphora nigra, 320.
New coccidæ, 142–43.
New destructive insects in New York, 61–65.
New fly trap, 110–12.
Newell, Wilmon, 55–61.
New York apple-tree canker, 178.
Nicotine, 244.
Norway maple, 422, 423, 424.
Notes on inspection, 259–60.
Nysius angustatus, 426.

Oak, 76, 77, 78, 79, 277, 301, 332, 410.
Oats, 117, 278, 362.
Oecanthus nigricornis, 177, 178, 180.
niveus, 177, 178.
quadripunctatus, 177, 178.
Oenothera hewetti, 489.
Oil of citronella, 348.
Oil insecticides on citrus trees and fruits, effects, 161–64.
of pennyroyal, 126.
of tar, 126.
Oligota oviformis, 86.
Onions, 231.
O'Kane, W. C., 153, 159.
Ophthalmia, 31.
Orange, 156, 190, 346, 362, 399.
Orange juice, 401.
Oregon coccinellidæ, 404–7.
Ornithodorus megnini, 223.
Ornix geminatella, 313.
Oryctes rhinoceros, 437.
Oxypleurites dentatus, 422.
dentilobis, 423.

Pamphilius dentatus, 199.
persicum, 199.
Panicum barbinode, 231.
Paracalocoris colon, 64.
Parasitology manuals, 416–18.
Paris green, 236, 440, 478, 479.
Parlatoria blanchardi, 186, 192, 415.
scale, 192.
Parrott, P. J., 61–65.
and Fulton, B. B., 177–80.
Paspalum membranaceum, 57.
Patch, E. M., 316–18.
Peach 156, 157, 177, 178, 180, 190, 193, 237, 238, 240, 263, 345, 400.
ecanium 164.
Peach saw fly, 199.
"Stop Back" and tarnished bug, 237–40.
twig borer, 238.
Peanuts, 362.
Pear, 62, 64, 157, 237, 238, 244, 396.
Psylla, fall spraying, 243–44.
thrips, 62, 65, 66.
Peas, 147, 148.
Pecan, 362.
Pellagra, 34, 113, 366, 374; sand-fly, II, 96–99.
Pepper tree, 191.
Peridroma margaritosa saucia, 192.
Perimeles remus, 249.
Perissopterus javensis, 294, 300, 303.
Peritoma serrulatum, New gall on, 279–80.
Persian walnut, 197, 199.
Peruvian fruit-fly, 345–46.
Petroleum, 126.
fuel oil, 162.
or petroleum products on dormant trees, injuries, 160–61.
Phæniococcus marlattii, 186, 192, 415.
Pheidole megacephala, 330.
Phlebotomus or sand-fly fever, 375.
Philæmatomyia insignis, 475.
Phyllobius argentatus, 63.
calcaratus, 63.
maculicornis, 63.
oblongus, 63.
pyri, 63.
viridicolles, 63.
Phyllocoptes brevisetosus, 423.
constrictus, 423.
magnificus, 423.
minutissimus, 423.
quinquilobus, 424.
splendidus, 424.
trilobis, 424.
variabilis, 424.
Phylloxera vastatrix, 190.
Physokermes insignicola, 298.
Phytalus smithii, 456, 457.
Phytonomus meles, 283.
Picudo of cotton in Peru, 303–12.
Pigeon pea, 325.
Pimpla (Itoplectis) conquisitor, 144–47.
Pine, 76, 78.
Pineapple, 68, 70, 71.
Pinus rigida, 331.
Piojo blanco of cotton, 318–27.
Piroplasma (Babesia), 219.
Pitch pine, 75.
Plague, 32, 35, 378.
Plant lice, 238.
Plasmodium, 219.
falciparum, 367.
vivax, 367.
Plum, 64, 156, 177, 263, 396.
Pocket mice, 224.
Podabrus pruinosus, 406, 457–59.
Pogonomyrmex barbata, 194.

Poison bait, 365.
Poliomyelitis, 30, 32, 34, 35, 103, 104, 105, 106, 107, 108, 109, 110, 113, 366, 375.
Polistes canadensis, 365.
Polydrosus mali, 63.
micans, 63.
sericeus, 63.
Pontia rapæ, 144.
Poplar, 63.
Porthetria dispar, 65.
Potato, 157.
Potato wart, 133.
beetle, 478.
Prenes nero, 257.
Prenolepis fulva, 256.
Prickly pear juice, 401.
Profenusa collaris, 63.
Pronuba yuccasella, 361.
Prospaltella aurantii, 319.
peruviana, 319.
Prune, 396.
Pseudococcus calceolariæ, 445, 450, 454, 455.
sacchari, 12, 251, 252, 253, 255, 455.
Psylla, 66.
Psyllobora tædata, 404.
Pteromalus puparum, 144.
Pulex avium, 84.
Pulvinaria vitis, 295.
Pumpkin, 362.
Pycnoderes quadrimaculatus, 190.

Quail, 365.
Quayle, H. J., 85–88; 290.

Raspberry, 177, 178.
Rats, 378.
Red ant, 330.
bugs, 64.
cedar, 76.
maple, 421, 422, 423, 424.
oak, 77, 177.
spider, 10, 85, 87.
Reduviid bugs, 105.
Remigia repanda, 231, 232, 233, 236, 257.
Rhagoletis cingulata, 79, 80.
fausta, 79, 80.
Rhinoceros beetles, 254, 437–42.
Rhizobius ventralis, 303.
Rhododendron borer, 427.
Rice, 54, 55, 56, 57, 58, 59, 60, 61, 117.
maggots, 59.
water weevil and its control, 55–61.
Riley, W. A., 416–18.
Rind disease, 256.
Ripersia festucæ, 143.
Rocky Mountain spotted fever, 200, 204, 210, 219, 220, 221, 222, 224.
Mountain spotted fever tick, 93–95; 200–11; 218.
Roëntgen rays, effect upon the cigarette beetle, 226–30.
Rose, 191, 192.
Rosenfeld, A. H. and Barber, T. C., 225.
Rosin, 162.
Rosin oil, 162.
Ross, E. H., 429.
Rosy apple aphis, 406, 457.
Rust red flour beetle, 40.
Rutabagas, 362.
Ryncophorus palmarum, 454.

Safro, V. I., 283.
Saissetia oleæ (nigra) 11, 293, 294, 298, 299, 301.
Salix caprea, 63.
Salt, 270.
Salt marsh mosquito, 352, 359.
Sand-fly, 96, 97, 99, 100.
Sanninoidea exitiosa, 193.
San José scale, 9, 66, 191, 263, 266, 267, 404; control, 270–73.
Sap fly, 285.
Sarcophaga georgiana, 365.
Sawtoothed grain beetle, 40.
Scapteriscus didactylus, 12, 252, 255; Cuban parasite of, 330.
Schedius kuvanæ, 298.
Schizoneura lanigera, 190.
Schœne, W. J., 157–58.
Scolia dorsata, 255.
Scolothrips sexmaculatus, 87.
Scrub pine, 331.
Scutellista cyanea, 301.
Scymnus kœwii, 149, 257.
roseicollis, 149, 257.
Severin, H. H. P., 68–73; 399–403.
and Severin, H. C., 347–51.
Shafer, G. D., 160.
Signiphora lutea, 320.
occidentalis, 320.
Silvanus surinamensis, 40.
Simulium vittatum, 97.
Sipha graminis, 149, 257.
Sleeping sickness, 27, 367, 376.
Smaller moth borer, 445, 446, 454.
Smilia misella, 404.
Snout beetles, 54.
Snow-ball aphis, 406.
Snowy tree-crickets, 177.
Soap, 157, 158.
Soft brown scale, 186, 191.
maple, 421.
scale, 293, 294, 300, 301, 302, 303.
Solenopsis geminata, 256, 312, 330.
pylades, 309.
Sorghum, 362, 455.
Southern grass worm, 230, 233, 236, 252, 257.
Soy bean, 362.
Spalaniga muscæ, 124.
Sphæropsis malorum, 178.
Sphenophorus sericeus, 252.
sexguttatus, 253.
Spiders and mites, natural enemies of, 85–88.
Spiny elm caterpillar, 157.

Spirochæta, 219.
Splenetic fever, 32, 33, 34.
Spotted fever, 31, 32, 33, 34, 380.
Squash, 190, 362, 402.
bug, 190.
capsid, 190.
Squirrels, 378.
Stable fly, 30, 100, 105, 112, 113, 115, 116, 217, 459; and infantile paralysis, 101–109; live stock, pest, 112–26; distribution, 459–77.
Stethorus picipes, 87.
Stomoxys calcitrans, 30, 32, 35, 101, 102, 105, 106, 109, 112, 366.
indica, 475.
sugillatrix, 470.
Stop back, 237.
Straw, 125, 126.
String beans, 362, 402.
Sugar beets, 410.
cane, 11, 134, 231, 232, 248, 249, 251, 252, 253, 254, 255, 256, 269, 362, 443–56.
froghopper, 191, 451.
leaf hopper, 455.
mealy bug, 450, 454, 455.
aphid, 149, 257.
beetle, 255.
insects in Porto Rico, 251–57.
mealy-bug, 12, 149, 252, 253, 255, 256.
moth stalk-borer, 12.
scale insect, 257.
Tingid, 247, 249–51.
maple, 285, 421, 422, 423, 424.
solution, 342.
Sulphuric acid, 161, 162.
Sulphur-lime, 9.
Sumac, 178.
Surface, H. A., 265–69.
Swarming of Hemiptera, 426.
Sweet corn, 188.
limes, 156.
potato, 362.
Sycamore, 178.

Tænipoda picticornis, 189.
Tanglefoot, 77.
Tannic acid, 400.
Tar, 440.
Targionia sacchari, 251, 257.
Tarnished plant bug, 237, 238, 239, 240.
Taxodium distichum, 278.
Tenebrioides mauritanicus, 40.
Tepper, J. G. O., 359–61.
Termes flavipes, 284.
morio, 257.
Terminalia catapa, 399.
Tetracha carolina, 364.
Tetranychus bimaculatus, 87.
mytilaspidis, 87.
sexmaculatus, 87.
Tetrastichus asparagi, 144.
Tetrastichus xanthomelænæ, 144.
Tettigonia octolineata, 410.
similis, 257.
Texas fever, 100, 114.
Thermal apparatus, 196–97.
Thriphleps insidiosus, 85.
Thrips, 237.
Ticks, 81, 104, 218, 219, 220, 221, 222, 223, 381.
Tides, rainfall and salt marsh mosquitoes, 352–59.
Timberlake, P. H., 293–303.
Tiphia parellela, 456, 457.
Tobacco, 232.
Tolype velleda, 426.
Tomaspis postica, 247.
varia, 247.
Tomocera californica, 294, 300, 301, 303.
Tomaspis postica, 453.
varia, 444, 451.
Tortrix sacrifaga, 252.
Townsend, C. H. T., 211-25; 244–46; 303–12; 318–27; 345–46.
Tree crickets, 177–80.
Triaspis vestiticida, 308.
Tribolium confusum, 40.
Trichogramma minutum, 341, 447, 454, 456.
pretiosa, 248, 254.
Trifolium, 284.
Trionymus americanus, 143.
californicus, 143.
nanus, 143.
violascens, 143.
Tropical almond, 399, 340, 400.
Trypanosoma, 219.
Trypanosoma casalboui, 112.
gambiense, 367.
pecaudia, 112.
rhodesiense, 367.
Trypanosomes, 376.
Trypanosomiasis, 27.
Trypeta ludens, 156, 269.
Tsetse flies, 376.
Tuberculosis, 32, 33, 34, 36.
Turnip, 238, 240, 362.
Two elm leaf aphides, 316–18.
Two-spray calendar, success of, 165–73.
Two-stabbed lady-bird beetle, 273.
Typhlocyba comes, 191.
Typhoid fever, 32, 33, 34.
fly, 460.
Typhus fever, 104, 383.

Unspotted tentiform leaf miner of the apple, 313–16.
Urich, F. W., 247–49.

Van Dine, D. L., 251–57.
Variegated cut worm, 192.
Vaseline, 327.
Velvet beans, 362.
Verruga fever, 211–25.
Vetch aphis, 457.

Walnut, 177, 410.
weevil, 197, 198.
weevil, bud moth and a sawfly, 197–99.
Washburn, F. L., 259–60; 327–29.
Wasp sting, effects of, 225.
Watermelon, 362.
Water weevil, 61.
Watson, J. R., 413–14.
Webster, R. L., 180–84; 409–13.
Weevil root-borer, 256, 455.
stalk-borer, 251, 252, 253, 450, 454, 455.
Weiss, H. B., 284, 407–9.
Wells, B. W., 330.
West Indian sugar-cane leaf-hopper, 252, 256.
Western leaf-footed plant bug, 186, 190.
Wheat, 36, 117, 362, 426, 470.
White ants, 284.
fly, 191.
grub, 252.
oak, 77.
pine, 75, 77, 79.
pine blister rust, 133.
scale of cotton, 9.
wash, 273.
Wilson, H. F., 457–59.
Witch hazel, 177.
Wild carrot, 180.
crab, 177.
tobacco, 191.
Willow, 63, 76, 157, 178, 325, 410.
beetle, 158.
Wilt disease, 332.
Woglum, R. S., 290.
Wolcutt, G. N., 443–57.
Woodchuck, 209.
Wooly aphis, 178, 190.

Xerophlæa viridis, 426.
Xyleborus affinis, 248.

Yellow fever, 28, 29, 30, 35, 100, 104, 217, 370.
Yothers, W. W., 161–64.
Yponomeuta malinellus, 64.
padellus, 64.
Yucca aloifolia, flowering and fruit-bearing of, 359–61.

Zebra caterpillar, 158.
Zinc arsenite and arsenate of lead tests, 157–58.
Zizania aquatica, 57.

POWER SPRAYING

would have saved these trees

This cut illustrates two of the several hundred beautiful elm trees, killed by the ELM LEAF BEETLE, in one of our largest University cities, because they were not sprayed.

Does a similar problem confront you?

If so, let us tell you about our method by which large trees may be sprayed for a few pennies each.

Among those using our HIGH DUTY sprayers are: United States Department of Agriculture; United States War Department; United States Capitol Grounds; District of Columbia; Massachusetts State Forester; Massachusetts Metropolitan Parks; Massachusetts Metropolitan Water and Sewerage Board; Cities of Boston, Mass.; Albany, N. Y.; Providence, R. I., and over 100 others.

We manufacture and sell over 90% of the HIGH DUTY sprayers used in the United States.

Catalog on request.

FITZHENRY-GUPTILL COMPANY

49 Washington Street, North
BOSTON, MASS.

135 First Street
EAST CAMBRIDGE, MASS.

Spraying for the ELM LEAF BEETLE with our Standard "A". United States Capitol Grounds.

INSECT PESTS

OF

FARM, GARDEN AND ORCHARD

BY

E. DWIGHT SANDERSON

DEAN OF THE COLLEGE OF AGRICULTURE, WEST VIRGINIA UNIVERSITY
DIRECTOR WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION

Large 12 mo. xii + 684 pages, 513 figures
Principally half-tones. Cloth, $3.00 net (12/6 net)

SECOND THOUSAND NOW READY

¶ It has been the author's effort to discuss all of the more important insects of farm, garden and orchard at sufficient length to give a clear idea of their life histories and habits, and also the best means of control, so that the book may be used as a reference work both by the student of economic entomology and by the practical farmer, gardener or fruit-grower. Insects of minor or local importance have been purposely omitted. The insects of practically all of the leading crops are considered, except the citrous fruits. With these the author is unfamiliar, but it is hoped to add a chapter upon them by a competent authority in a subsequent edition. In general, the discussion of insects and their control as given is based upon conditions east of the Rockies, and practically no consideration has been given to the conditions of the Pacific Coast or of the irrigated country of the far West.

JOHN WILEY & SONS, Inc.

432 FOURTH AVENUE
NEW YORK CITY

London, Chapman & Hall, Ltd. **Montreal, Can., Renouf Pub. Co.**

SWIFT'S

Arsenate of Lead

STANDS FOR

Quality and Efficiency

Manufactured Only By The

MERRIMAC CHEMICAL COMPANY

BOSTON, - - - - MASS.

HEMINGWAY'S

is the lead arsenate of the expert fruit grower. It is widely used in all of the famous fruit growing districts. Made in a factory which has specialized in arsenical manufactures for over 30 years, it has the advantage of this long experience in its preparation for the use of the discriminating fruit grower.

HEMINGWAY'S ARSENATE OF LEAD

The Perfect Product.

Possesses miscibility with maximum sticking power.
Is 20% stronger than the federal law requires.
Send for booklet giving full directions for the use of Hemingway's Lead Arsenate against all biting insects.

HEMINGWAY'S LONDON PURPLE CO., LTD.
17 Battery Place, New York

TROPICAL DISEASES BULLETIN

PUBLISHED FORTNIGHTLY

Under the General Editorship of the Director of the Tropical Diseases Bureau, Imperial Institute—
A. G. BAGSHAWE, M. B., D. P. H. Cantab.

In November, 1912, the Tropical Diseases Bureau, which replaced the Sleeping Sickness Bureau on July 1st, 1912, commenced the publication of the "Tropical Diseases Bulletin." The tropical and sub-tropical diseases of man are grouped in sections, which are in charge of the following Sectional Editors:

Fleet-Surgeon P. W. BASSETT-SMITH, C. B.
Lieut.-Col. C. BIRT, R. A. M. C.
ANDREW BALFOUR, C. M. G., M. D., D. P. R. Cantab.
ALDO CASTELLANI, M. D.
Captain S. R. DOUGLAS, I. M. S. (ret'd)
H. B. FANTHAM, D. Sc.
Dr. EDWARD HINDLE
R. T. LEIPER, D. Sc., M. B., Ch. B.
F. M. SANDWITH, M. D., F. R. C. D.
J. HENDERSON SMITH, M. B., Ch. B.
C. M. WENYON, B. Sc., M. B., B. S.
WARRINGTON YORK, M. D.

The Honorary Managing Committee and Staff of the Bureau are as follows:

Chairman:—THE RIGHT HONOURABLE SIR J. WEST RIDGEWAY, G. C. B., G. C. M. G., K. C. S. I., LL. D.

Sir JOHN ROSE BRADFORD, K. C. M. G., F. R. S.
Surgeon-General Sir DAVID BRUCE, C. B., F. R. S.
Surgeon-General Sir HAVELOCK CHARLES, I. M. S., G. C. V. D.
Bt.-Lieut.-Colonel Sir WILLIAM B. LEISHMAN, R. A. M. C., F. R. S.
Sir JOHN M'FADYEAN, M. R. C. V. S.
Sir PATRICK MANSON, G. C. M. G., F. R. S.
Sir RONALD ROSS, K. C. B., F. R. S.
STEWART STOCKMAN, M. R. C. V. S.
J. A. C. TILLEY (Representing the Foreign Office and Sudan Government)
H. J. READ, C. M. G. (Representing the Colonial Office),
WITH
A. BERRIEDALE KEITH, M. A., D. C. L., of the Colonial Office, as Secretary.

Assistant Director:—G. C. LOW, M. A., M. D., Lecturer, London School of Tropical Medicine.
Librarian:—R. L. SHEPPARD.

ANNUAL SUBSCRIPTION, £1 1s. post free. **SINGLE NUMBERS, 1s. 6d.**

The Roessler & Hasslacher Chemical Co.

100 William Street, New York
Works: Perth Amboy, N. J.

THE ROESSLER & HASSLACHER CHEMICAL COMPANY — CHEMISTS — NEW YORK — TRADE MARK

FUMIGATING CYANIDE

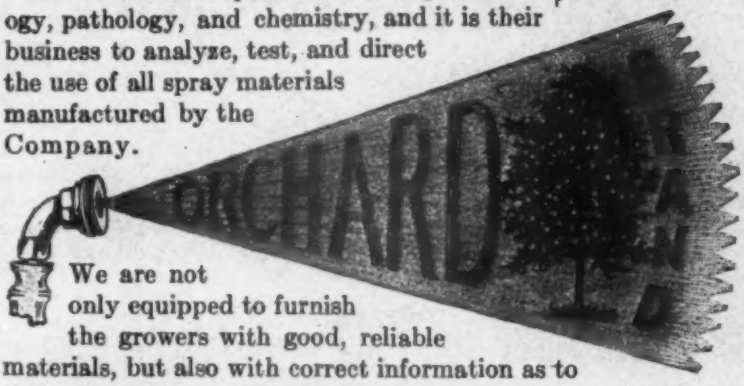
For generating Hydrocyanic Acid Gas.

The only positive eradicator of the San José Scale, Red and Black Scale and other insect pests.

"ORCHARD BRAND" SPRAY MATERIALS

Will be furnished free of charge, in small quantities, to entomologists and pathologists for experimental purposes. We want our materials tested and retested in order that we may correct any defects that may be detected. "Orchard Brand" Spray Materials represent the highest standard of quality and efficiency and it is our purpose to maintain this standard at any cost.

Our Research Department is composed of experts in entomology, pathology, and chemistry, and it is their business to analyze, test, and direct the use of all spray materials manufactured by the Company.



We are not only equipped to furnish the growers with good, reliable materials, but also with correct information as to their uses in the treatment of insects and diseases. The following is a partial list of our products:

Lime-Sulphur Solution	Atomic Sulphur
Soluble Oil	Bordeaux Mixture—Paste
Arsenate of Lead—Standard	Bordeaux Mixture—Powder
Arsenate of Lead—Tri-plumbic	Bordeaux-Arsenate of Lead mixture
Arsenate of Lead—Powder	Bordeaux-Arsenite of Zinc mixture
Arsenite of Zinc—Paste	Blue Stone
Arsenite of Zinc—Powder	Sulphur

C. P. Chemicals

THOMSEN CHEMICAL COMPANY

BALTIMORE, MD.

BRANCHES:

Syracuse, N. Y. St. Louis, Mo. Fort Valley, Ga.
San Francisco, Cal.

TO DESTROY

APHIS, THRIPS, PEAR PSYLLA, GRAPE LEAF HOPPER, Etc.

WITHOUT INJURY TO FOLIAGE

SPRAY WITH

"BLACK LEAF 40"

A CONCENTRATED SOLUTION OF NICOTINE SULPHATE.

"Black Leaf 40" is highly recommended by experiment stations and spraying experts throughout the entire United States.

Owing to the large dilution, neither foliage nor fruit is stained.

Also, "Black Leaf 40" is perfectly soluble in water—no clogging of nozzles.

PRICES:

10½-lb. Can. $12.50 Makes 1600 to 2100 gallons for Pear Thrips, with addition of 3 per cent. distillate oil emulsion; or, about 1100 gallons for Green Aphis, Pear Psylla, Hop Louse, etc., or about 850 gallons for Black Aphis and Woolly Aphis—with addition of three or four pounds of any good laundry soap to each 100 gallons of water.

2½-lb. Can, $3.25.

½-lb. Can, 0.85.

If you cannot obtain "Black Leaf 40" from a local dealer, send us P. O. Money Order, and we will ship you by express at the above prices, prepaying the expressage to your nearest railroad town in the United States.

KENTUCKY TOBACCO PRODUCT CO.

INCORPORATED

LOUISVILLE, KY., U. S. A.

THE KNY-SCHEERER CO.
DEPARTMENT OF NATURAL SCIENCE
404–410 W. 27th St. NEW YORK, N. Y.

LEPIDOPTERA BOXES
GREATLY IMPROVED

12 x 8 in., lined with compressed turf, $5.00 per doz.
Lined with Asta cork, $6.00 per doz.

SCHMITT BOXES.

First lot of 1000 Standard style will be ready within a few weeks.
Sample box at $1.00

EXHIBITION CASES.

8 x 11 x 2½", plain,	$0.75
12 x 16 x 2½" "	1.50
14 x 22 x 2½" "	2.00

GET THE BEST

A Good Spray Pump earns big profits and lasts for years.

THE ECLIPSE

is a good pump. As practical fruit growers we were using common sprayers in our own orchards—found their defects and invented the Eclipse. Its success forced us to manufacturing on a large scale. You take no chances. We have done all the experimenting! Large, fully illustrated Catalog and Treatise on spraying **Free.**

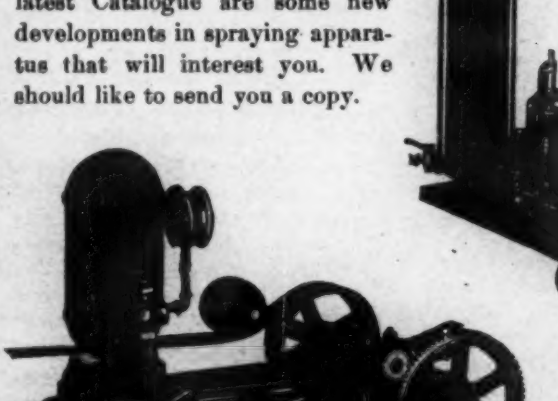
MORRILL & MORLEY MFG. CO.
Box 9, Benton Harbor, Michigan

Destroy Tree Pests
Kill San Jose Scale, Apple Scab, Fungi, lice, bugs and other enemies of vegetation by spraying with
GOOD'S CAUSTIC POTASH FISH OIL SOAP No. 3
Does not harm the trees— fertilizes the soil and aids healthy growth. Used and endorsed by U. S. Dept. of Agriculture. FREE.—Our valuable book on Tree and Plant Diseases. Write for it today.
JAMES GOOD, Orig'l Maker 939-41 N. Front St., Phila.

Deming Sprayers

Known the world over as "THE WORLD'S BEST"

All the subscribers to this paper are undoubtedly familiar with Deming Pumps, and many of you have operated them. In our latest Catalogue are some new developments in spraying apparatus that will interest you. We should like to send you a copy.



The above cut illustrates our famous "Sampson" double acting hand sprayer with upright lever. The picture to the left is our Fig. 765 double acting power sprayer which can be belted to any engine and is good for 200 lbs. pressure.

The Deming Company 18 Depot St., Salem, Ohio

MANUFACTURERS OF

HAND AND POWER PUMPS FOR ALL USES

General Distributing Houses in All Principal Cities

Drawn from Actual Photograph taken at Melrose, Mass. TREE TANGLE-FOOT saved the tree on the left; Gypsy Moths stripped the tree on the right

Band With Tree Tanglefoot!

No Creeping Insect Escapes Its Sticky, Deadly Grip!

The destroying army is coming! Don't wait until you see the vanguard. Band your trees with Tree Tanglefoot two weeks before the Gypsy, Browntail and Tussock Moth Caterpillars and Canker Worms, Climbing Cut Worms and Bag Worms begin their ravaging work.

Easily and Quickly Applied With a Wooden Paddle

Tree Tanglefoot is harmless and the only sure and safe protective. One pound makes about nine lineal feet of band. One coating lasts three months and longer in any temperature, rain or shine. Remains sticky and powerful twenty times as long as any other substance. Needs no mixing—just open the can and apply.

Will not soften or run down the trunks of the trees. Absolutely prevents any creeping, crawling pests from harming your trees.

Sold by Reliable Seed Houses

Prices:

1-lb. cans,	30c	10-lb. cans,	$2.65
3-lb. cans,	85c	20-lb. cans,	$4.80

Write us today for valuable free booklet and name of nearest dealer.

The O. & W. Thum Company

Manufacturers of Tanglefoot Fly Paper and Tree Tanglefoot

Dept. O Grand Rapids, Mich.

IMPORTANT NOTICE TO ALL SUBSCRIBERS

All Subscribers are requested to notify the Business Manager if any change of Address is desired.

The Mailing List is carefully prepared for each issue and each subscriber is requested to immediately report any failure to receive the Journal. Unless such Notice is received from Subscribers in the United States within sixty days or from foreign Subscribers within ninety days from date of mailing the issues, the missing numbers will be furnished only at the regular published rate.

SPENCER MICROSCOPES

ARE BUILT FROM THE

LABORATORY WORKER'S STANDPOINT

There are incorporated in them many features of practical usability, features which make for convenience and comfort in use as well as efficiency and durability and which mark them as best adapted to their purpose.

SPENCER MICROSCOPES

EXCEL IN

I. OPTICAL SUPERIORITY.
II. MECHANICAL PERFECTION.
III. EMBODIMENT OF IMPROVEMENTS WHICH MARK THEM AS BEST ADAPTED TO THEIR PURPOSE.

SPENCER OPTICS
HAVE STOOD UNSURPASSED
FOR OVER HALF A CENTURY

No. 66 B Equipped with 16m/m and 4m/m objectives. Double nosepiece. One eyepiece. Iris diaphragm. Complete in Cabinet. Discount to schools. **$31.50**

GET OUR QUOTATIONS

SPENCER LENS CO.
BUFFALO, N. Y.

Ward's Natural Science Establishment

84-102 COLLEGE AVE., ROCHESTER, N. Y.

Having recently purchased the entire stock of the American Entomological Co., of Brooklyn, we are now prepared to furnish **Entomological Specimens and Supplies of all kinds.**

We believe our stock to be the largest in this country, if not in the world, and we solicit your patronage.

Our prices are made as low as is possible, considering the quality of the material furnished.

We manufacture the only genuine Schmitt Boxes and the American Entomological Co. Insect Pins.

We shall prepare from time to time special lists of choice material, and will mail these free to those whose names are on our mailing list.

If interested in other branches of natural history write for our Circular E-100, listing our numerous price lists.

Founded 1862 **Incorporated 1890**

Arsenate of Lead

Lime Sulphur Solution

GRASSELLI ARSENATE OF LEAD

A RELIABLE INSECTICIDE.

Successfully used in all the large fruit growing sections.

GRASSELLI LIME SULPHUR SOLUTION.

¶ For control of San Jose Scale, Blister Mite, and similar scale or sucking insects.

¶ Also an efficient Fungicide.

¶ It has been found especially satisfactory as a substitute for Bordeaux Mixture to control Fungous Diseases of Apples and Pears.

GRASSELLI SPRAY PRODUCTS are guaranteed to comply with the Insecticide Act of 1910.

THE GRASSELLI CHEMICAL COMPANY

ESTABLISHED 1839.

Main Office: CLEVELAND, OHIO.

BRANCH OFFICES:

New York, 80 Maiden Lane
Chicago, Ill., 2235 Ford Ave.
Birmingham, Ala., 825 Woodward Bldg.
St. Paul, Minn., 172-174 East 5th St.
Cincinnati, O., Pearl St. and Eggleston Ave.
Boston, Mass., 70 Kilby St.
St. Louis, Mo., 112 Ferry St.
Milwaukee, Wis., Canal and 16th Sts.
Detroit, Mich., 474-486 Hancock Ave., East.
Dothan, Ala.
New Orleans, La., Godchaux Bldg.
Pittsburg, Pa., Diamond Bank Bk.
Philadelphia, Pa., Drexel Bldg.
Beaver Falls, Pa.

SEND INQUIRIES AND ORDERS TO NEAREST BRANCH OFFICE.

THE GRASSELLI CHEMICAL COMPANY, LTD.

HEAD OFFICE AND WORKS, Hamilton, Ontario.

BRANCH OFFICES: { Toronto, Ontario, Pope and Gerrard Aves.
Montreal, Quebec, 103 Nazareth St.

The Slingerland Lantern Slides

Photographed and Colored from Nature

Life-histories of Butterflies and Moths :: :: Injurious Insects
Trees and Fruits :: :: Birds and other Nature-study Subjects

... Send for List ...

Mrs. M. V. Slingerland, Ithaca, New York